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April 17, 2011

VIA EXPRESS MAIL

Rosemary Chiavetta, Secretary
Pennsylvania Public Utility Commission
Commonwealth Keystone Building
400 North Street
Harrisburg, PA 19120

Re: Act 129 Energy Efficiency and Conservation Program - Phase Two
Docket No. M-2012-2289411

Dear Secretary Chiavetta:

Enclosed for filing, please find an original and three copies of the comments of the UGI Distribution Companies ("UGI") submitted to the above docket. A copy of these comments has also been e-mailed to Megan G. Good at megagood@pa.gov.

Should you have any questions concerning these comments, please feel free to contact me.

Very truly yours,

Mark C. Morrow

Counsel for the UGI Distribution Companies

BEFORE THE
PENNSYLVANIA PUBLIC UTILITY COMMISSION

Act 129 Energy Efficiency and Conservation Program - Phase Two	:	Docket No. M-2012-2289411

COMMENTS OF THE UGI DISTRIBUTION COMPANIES

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I. INTRODUCTION

The UGI Distribution Companies ("UGI")[1] appreciates this opportunity to submit comments in response to the Commission's March 1, 2012 Secretarial Letter at the above docket. UGI provides natural gas distribution service to in excess of 594,000 customers, and is the largest provider of natural gas distribution service in Pennsylvania. UGI's affiliated electric distribution company, UGI Utilities, Inc. – Electric Division ("UGI-ED"), provides electric distribution service to approximately 62,000 customers in Pennsylvania. Although UGI-ED is not subject to the provisions of Act 129,[2] consistent with the provisions of the Commission's December 23, 2009, Secretarial Letter at Docket No. M-2009-2142851, UGI-ED filed a voluntary Energy Efficiency and Conservation ("EE&C") plan with the Commission which was approved with modifications in Commission Orders entered on October 19, 2011 and March 16, 2012 at Docket No. M-2010-2210316. The UGI-ED EE&C plan, which will be implemented on or about June 1, 2012, includes cost-effective fuel substitution measures.

II. COMMENTS

[1] For the purposes of this filing the UGI Distribution Companies are comprised of UGI Utilities, Inc. – Gas Division, UGI Penn Natural Gas, Inc. and UGI Central Penn Gas, Inc.
[2] Under the provisions of 66 Pa. C.S. § 2806.1(l), EDCs serving less than 100,000 customers are not subject to the provisions of Act 129.

UGI agrees with the sentiments expressed in Chairman Powelson's March 1, 2012, statement at this docket, which noted that as the Commission considers the implementation of a second round of Act 129 programs, it is essential that the Commission "have all of the facts … to ensure the costs and benefits of these programs truly weigh in on the side of consumers" and that "any future Act 129 programs are effective uses of consumers' money."

To ensure that the Commission "has all the facts" before it, UGI believes the Commission should:

- Ensure that all interested stakeholders are given a fair opportunity to present proposals to the Commission for meeting EDC energy and peak load reduction goals along with appropriate cost benefits analyses under the Total Resource Cost ("TRC") test; and
- To facilitate "apples to apples" comparisons of potential program measures, procedures should be put in place to make sure that stakeholders presenting proposals and the supporting TRC test analyses for the Commission's consideration have a fair opportunity to gain access to the assumptions underlying EDC TRC test analyses, included avoided cost estimates; and
- Consider, to the extent it is deemed helpful to the Commission's understanding of available options, facilitating additional working groups with Commission staff and other interested stakeholders to address any potential barriers to the consideration of certain program measures, such as cogeneration or fuel substitution.

To ensure that "any future Act 129 programs are effective uses of consumers' money", in turn, UGI believes that the Commission should:

- Provide a clear signal that it expects EDCs to select program measures which are the most cost-effective under the TRC test within each customer segment, even if the program measures were not initially proposed by an EDC; and
- Consider requiring EDCs to propose certain specified program measures in their Act 129 filings, specifically cogeneration and fuel substitution programs, or to explain why they did not do so and why the alternatives selected are more cost-effective under the TRC test (and a more effective use of consumer money) to ensure that EDC's are appropriately prepared to adopt alternative, cost-effective program measures in their Act 129 programs.

In the first round of Act 129 filings, PECO Energy, and to a much more limited extent, PPL, proposed fuel substitution measures in their Act 129 plans. UGI and other NGDCs, in turn, intervened in several EDC Act 129 proceedings and proposed new or additional fuel substitution program measures supported by TRC test analyses that often had to rely on independently calculated assumptions given the confidential status afforded certain assumptions underlying EDC TRC test analyses. UGI and other NGDCs also asked the Commission at that time to require EDCs to track Act 129 program measure recipient conversions from alternate, and perhaps more efficient, energy sources to electricity in order to determine if the EDC's Act 129 incentives were creating unintended consequences in the marketplace.

In response, EDCs raised a number of objections, including (1) the lack of clear rules from the Commission concerning how fuel substitution measures would be handled under the TRC, (2) the recent volatility in gas prices, (3) how the inclusion of new, un-anticipated programs would disrupt the balance of the programs they had originally selected and (4) the lack of time to consider new approaches given the tight statutory deadlines imposed by ACT 129.

In its orders addressing the first round of Act 129 EE&C program proposals, the Commission approved the fuel substitution programs proposed by PECO Energy and PPL and referred other fuel substitution proposals to a Commission-sponsored working group. The Commission also ordered most EDCs to track conversions by Act 129 program measure recipients from alternate energy sources to electricity.

In the subsequent fuel substitution working group, the Commission's Bureau of CEEP played a vital role in gathering confidential assumptions underlying EDC TRC test analyses and providing averaged values for use in modeling fuel substitution programs, including programs for water heater conversions, space heating conversions, clothes dryer conversions and various combined heat and power (cogeneration) programs. These models can be accessed under the "Electricity - Act 129 Information – Fuel Substitution Working Group" tabs of the Commission's website and, except for the Micro Combined Heat and Power (cogeneration) analysis, clearly indicated that fuel substitution programs could be very cost-effective under the TRC test (and often more cost effective then program measures adopted in the first round of Act 129 programs).

Thereafter, an April 30, 2010 staff report was issued making certain recommendations which the Commission adopted in a May 21, 2010, Secretarial Letter at Docket No. M-00051865. Those recommendations were:

- *Cost-effective fuel switching measures should be available to EDCs and their stakeholders when considering the best means of achieving EE&C plan goals. However, fuel switching programs should not be mandated.*
- *EDCs should address the design of fuel switching programs through their stakeholder processes.*

- *The most effective manner in which to develop guidance to determine efficiency standards for any equipment involved in a fuel switching program is through the TRM and TRC test revision processes.*

- *Custom evaluation, measurement and verification methods for determining electric consumption and demand reductions associated with fuel switching programs should be developed by each EDC's independent monitor and approved by the Director of the Bureau of Conservation, Economics and Energy Planning.*

- *Any proposed deemed savings associated with specific fuel switching measures should be reviewed under the TRM update process.*

- *EDCs be permitted to consider fuel switching programs for low income customers.*

- *The Commission release this Report and adopt, reject, modify or add to the Staff's recommendations contained in it.*

- *That the Commission direct CEEP to develop deemed evaluation, measurement and verification protocols for specific energy efficiency measures that involve switching from electricity to another fuel source, to be considered for inclusion in the TRM. CEEP is to develop these protocols in conjunction with the Statewide Evaluator and through the annual TRM revision process.*

- *The Commission direct CEEP to develop recommended changes to the TRC test needed to analyze the costs and benefits of energy efficiency measures that involve switching from electricity to another fuel source. CEEP is to develop these recommended changes to the TRC test in conjunction with the Statewide Evaluator and the Total Resource Cost Test Working Group.*

UGI believes that each of the tasks assigned to the Bureau of CEEP in the May 21, 2010, Secretarial Letter have now been completed and that the Commission and its staff should be commended for the important work they have performed in laying the foundation for future Act 129 fuel substitution programs.

UGI also believes, given the reduction in gas prices relative to electric prices over the last several years, if updated cost information were used in the model fuel substitution program TRC test analyses set forth on the Commission's website, the cost effectiveness of the model programs would be even more beneficial.

Given the issuance date of the May 21, 2010, Secretarial Letter, it is perhaps understandable that the Commission did not "mandate" fuel substitution programs, but as the Commission considers its approach to the second round of Act 129 programs, UGI believes the Commission should be mindful of the potential bias of EDCs for programs favoring incremental gains in the efficiency of electric appliances, rather than programs eliminating the use of electricity for certain heating purposes, and should consider taking a more proactive role in making sure that the most cost-effective programs for consumers are selected.

Specifically, UGI cites the following points to support its belief that the Commission should consider requiring EDCs to evaluate fuel substitution programs in their second round of Act 129 EE&C program development:

- the extensive work that has already been performed by Commission staff and other stakeholders to develop model fuel substitution program TRC test analyses and incorporate these measures into the TRM;
- the considerable cost effectiveness of fuel substitution measures is shown under these analyses;
- the "game-changing" super-abundance of natural gas from shale formations, including Pennsylvania Marcellus shale, makes natural gas an even more compelling alternative source of energy (when compared to electricity under a total fuel cycle analysis) for heating and combined heat and power (cogeneration) purposes;
- the traditional resistance shown by EDCs to voluntarily adopting fuel substitution programs and the natural reluctance of EDCs to incorporate substitute program measures

after expending resources to develop comprehensive and interconnected EE&C programs

UGI also believes the Commission should consider requiring EDCs to either propose such programs in their Act 129 filings or explain why such programs have not been selected and why any selected alternatives are more cost-effective and a better use of customer funds. Moreover, the Commission should assure EDCs include cogeneration and fuel substitution programs which have sufficient size and funding so as to assure these programs are not simply provided cursory "lip-service."

It is very important for the Commission to keep in mind, as it moves forward in setting policies for the next round of Act 129 filings, why the direct end use of natural gas for heating purposes, presents such a compelling opportunity to improve the Commonwealth's energy efficiency and overall consumer benefit.

Delivering natural gas to consumers' homes and businesses and burning it on site to produce heat results in an approximately three-to-one energy gain over converting fuels into electricity at a remote location and then transmitting and distributing it to homes and businesses for the purpose of generating heat. That is because about two thirds of the energy potential of the fuels used to generate electricity is lost in the process of converting those fuels into electricity and incurring the associated line losses for transmission and distribution. Indeed, the largest use of energy to serve residential and commercial customers in the United States is for the losses associated with generating and delivering electricity. Obviously, to the extent such losses can be minimized through the direct use of natural gas, tremendous gains in efficiency can be achieved. Stated differently, if our nation's current projected 100+ year reserve supply of natural gas was used in direct use natural gas applications, as compared to fueling traditional electric generation, our reserve could last for approximately 300 years or more.

Inclusion of cost effective fuel switching as part of second round Act 129 filings would not only benefit homes and business directly connected to the gas distribution grid in Pennsylvania, but would also benefit Pennsylvania energy consumers to a greater extent by placing increased downward pressure on wholesale electric prices, which in turn would place downward pressure on the prices of competing energy sources. It would also establish Pennsylvania as a model for other states in our nation to follow.

Extensive and detailed information about the energy efficiency gains associated with the direct end use of natural gas, and value that can be delivered to consumers, and policy actions that might be taken to increase energy efficiency through the direct end use of natural gas can be accessed at the American Gas Association website at http://www.aga.org, and clicking on the "Squeezing Every BTU" tab. For the convenience of the Commission, a copy of the Squeezing Every BTU report and Executive Summary, prepared in January of 2012, is attached.

The overall potential for energy and consumer savings through the direct end use of natural gas was addressed in a June 29, 2009 GTI study which found that policies promoting the direct end use of natural gas nationwide could result in $213 billion in consumer savings, create 200,000 GWh of annual energy savings, avoid the need for 50 GWh of new electric capacity and reduce CO2 emissions by 96 million metric tons per year by 2030. This study can also be accessed on AGA website by typing "2009 GTI Study" into the search bar.

Finally, UGI would note that in 2011 the Unites States Department of Energy adopted its "Energy Conservation Program for Consumer Products and Certain Commercial and Industrial Equipment: Statement of Policy for Adopting Full-Fuel-Cycle Analyses into Energy

Conservation Standard Program" at Docket No. EERE-2010-BT-NOA-0028, RIN 1904-AC24 (published in the August 18, 2011 edition of the Federal Register) which endorsed the full-fuel-cycle method of measuring energy efficiency and adopted this as its preferred method for providing information to consumers about energy efficiency.

Accordingly, UGI encourages the Commission to assure second round Act 129 plans filed by EDCs appropriately address the tremendous energy saving potential which can be achieved through the inclusion of properly designed fuel substation programs.

Respectfully submitted,

Mark C. Morrow

Counsel for the UGI Distribution Companies

Dated: April 17, 2012

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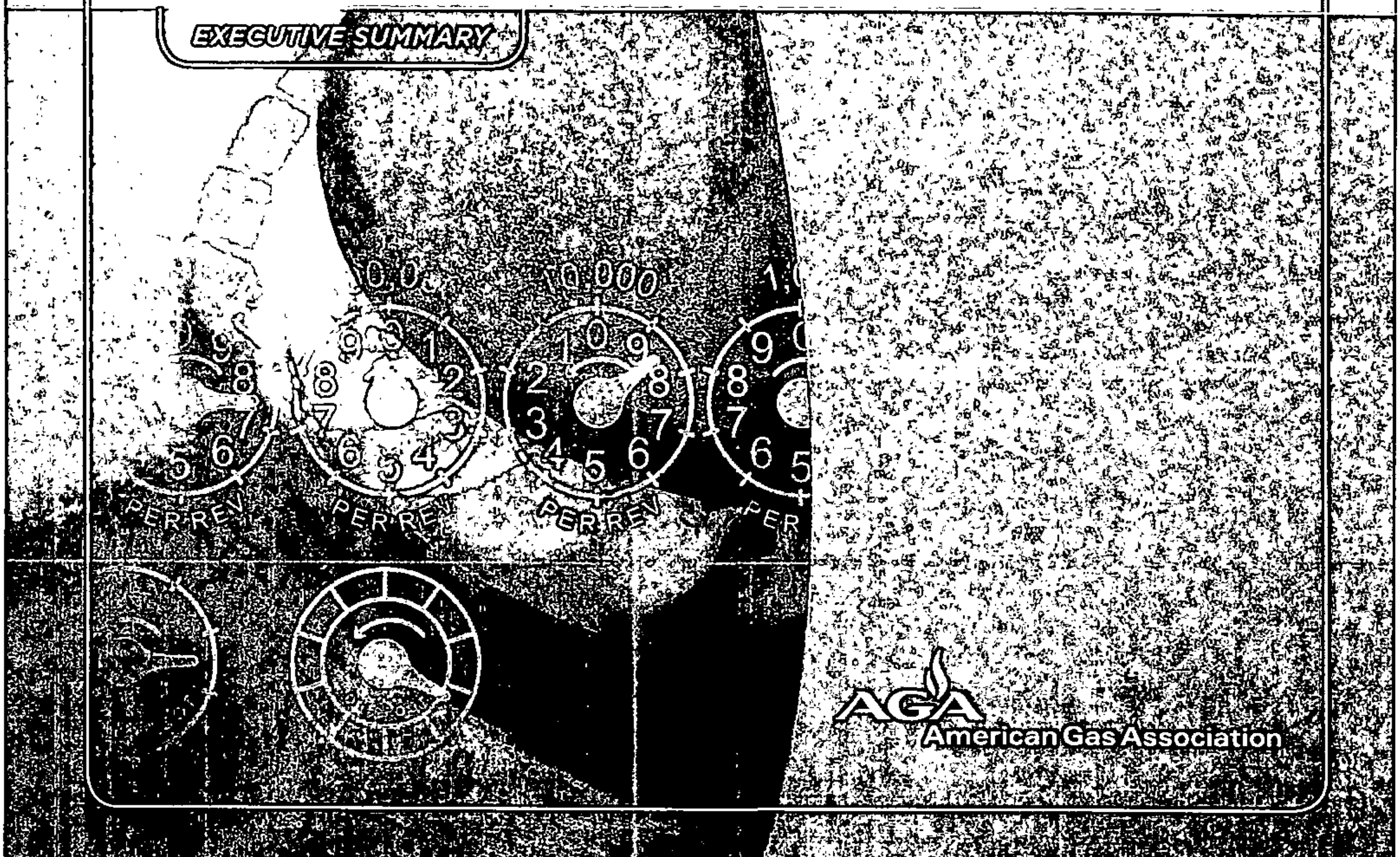
APPENDIX A

(January 12, 2012 AGA Executive Summary and Study)

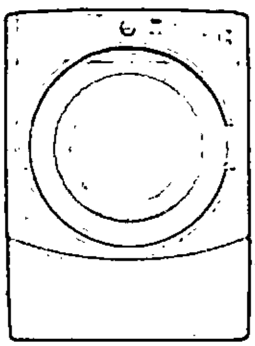
Squeezing Every BTU:

Natural Gas Direct Use Opportunities and Challenges

EXECUTIVE SUMMARY



AGA
American Gas Association

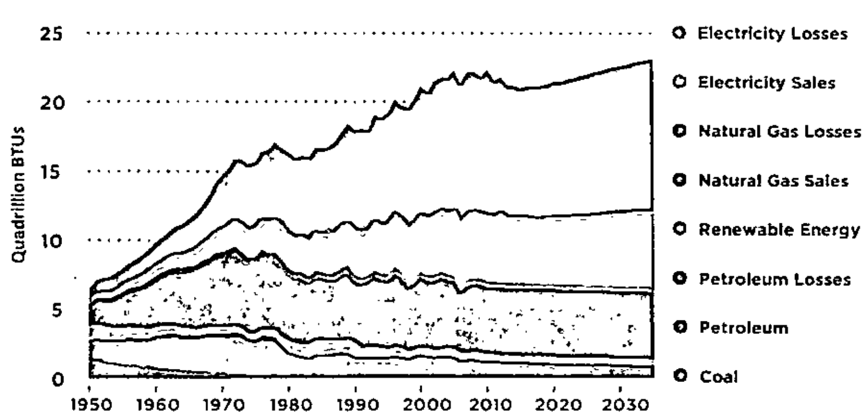


Households with natural gas heating, cooking and drying appliances on average spend almost 30 percent less than households with all-electric appliances.

Today's society is more reliant on energy than ever before, and natural gas is a critical component of today's energy mix. In 2012, natural gas will be used in more than 70 million households and businesses, serving more than 40 percent of the direct energy needs of the nation's homes and buildings. Natural gas will fuel almost one quarter of electricity generation. Industry will rely on natural gas as fuel for manufacturing and as a feedstock to create fertilizers for use by farmers. It is environmentally superior to coal and petroleum, producing low pollution and half the greenhouse gas emissions of other fossil fuels, and natural gas provides the foundation to unlock the potential of renewable solar and wind energy. The vast abundance of domestic natural gas available in North America holds the potential to power our nation for more than 100 years and will be central to the nation's energy future.

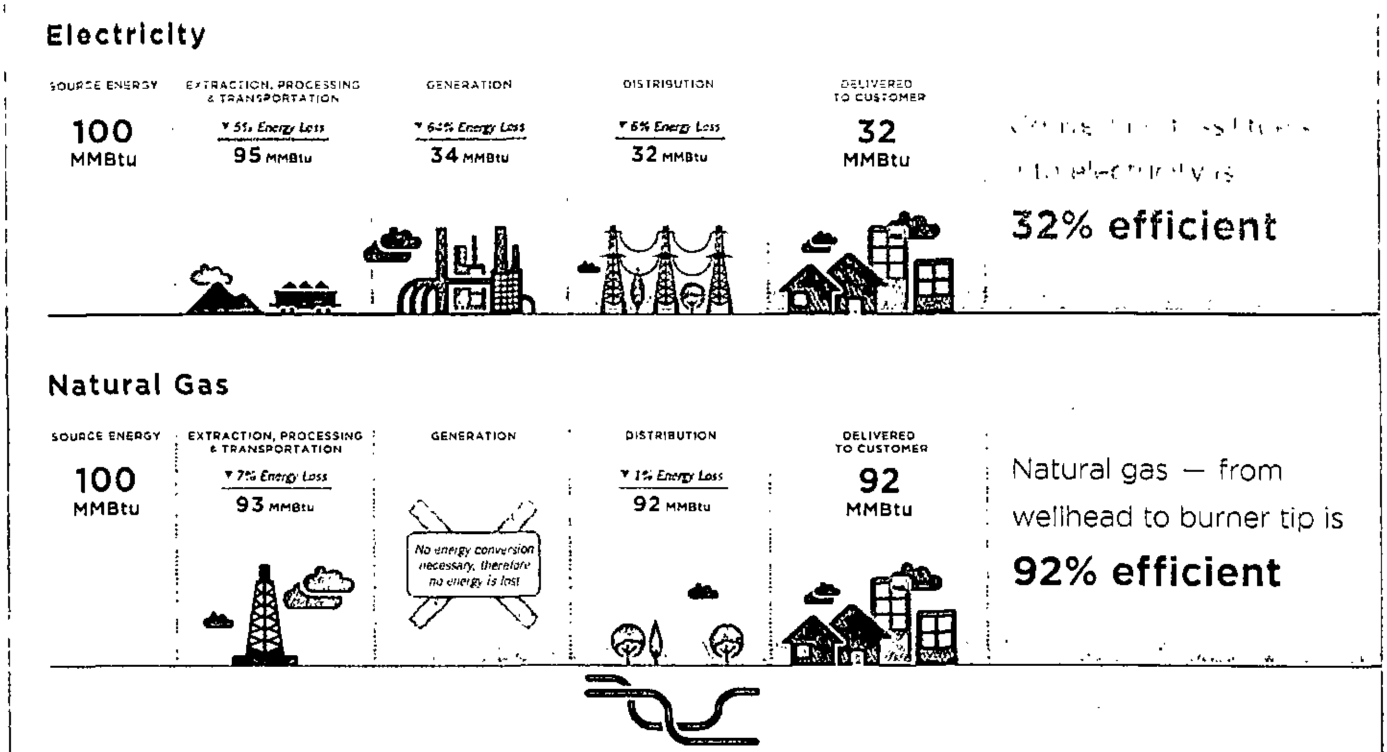
Squeezing Every BTU is about the benefits of the direct use of natural gas, and how we can utilize this domestic resource productively and efficiently to provide value to consumers, create jobs here at home, and spur the economy.

Residential Sector Energy Consumption History and Projection



The direct use of natural gas has significantly fewer energy losses compared with electricity. A full-fuel-cycle approach incorporates source-to-site efficiencies along with the end-use appliance efficiency.

Source: U.S. Energy Information Administration (EIA)



In most cases, the direct use of natural gas has significantly fewer energy losses compared with electricity.[1] A full-fuel-cycle approach incorporates source-to-site efficiencies along with the end-use appliance efficiency.

Direct use of natural gas in the residential and commercial sectors

Direct use refers to natural gas consumed directly in appliances for heating and cooling, water heating, cooking, and clothes-drying. In contrast, many consumers use natural gas indirectly by consuming electricity generated with natural gas. The significance of this distinction is that the natural gas distribution system is generally more efficient than electricity since it avoids the loss of useable energy that results from electricity generation, transmission, and distribution. The energy lost amounts to nearly half the energy used in homes and commercial businesses according to the U.S. Energy Information Administration.

The direct use of natural gas provides a cost-effective and resource-efficient choice for consumers and offers one more option in the suite of greenhouse gas emissions reductions strategies. And direct use makes financial sense as a consumer fuel choice. A household with natural gas usually spends less on heating, cooking, and drying than one using any other fuel. A recent AGA analysis showed that a household with natural gas heating, cooking and drying appliances on average spends almost 30 percent less than a household with all-electric appliances, and results in 37 percent lower greenhouse gas emissions.[2]

BENEFITS OF NATURAL GAS DIRECT USE

- Lower consumer energy bills
- Increased productivity of energy supplies
- Reduced energy imports
- Fewer pollutants and greenhouse gas emissions
- Reduced new electric power requirements
- Enhanced domestic energy security
- Safe and reliable

1 *Source Energy and Emission Factors for Building Energy Consumption*, Prepared by the Gas Technology Institute for the Codes & Standards Research Consortium, August 2009.

2 American Gas Association, "A Comparison of Energy Use, Operating Costs, and Carbon Dioxide Emissions of Home Appliances." 2009. http://www.aga.org/Kc/analyses-and-statistics/studies/demand/Documents/0910EA3.PDF

The direct use of natural gas offers more advantages for the consumer and for the environment compared with all other fuels available to homes and businesses.

	Direct Use Natural Gas	Heating Oil	Propane	Electricity (by Generation Fuel): Coal	Coal Carbon Capture	Solar / Wind	New Nuclear	New Gas
Cost effective	● +			●				●
Resource efficiency	● +					●	○	●
Resource availability	●			●	●	●	○	●
Enhances energy security	●			●	●	●	○	●
Lowers carbon emissions	●		○		●	●	○	●
Reliable / proven technology	●	○	○	●		●	○	●
Regulatory certainty	●	○	○					

LIMITS AND CONSTRAINTS ON NATURAL GAS DIRECT USE

- **Appliance first cost**
  Gas appliances and supporting equipment often incur higher installation and up-front costs compared to alternative fuel applications
- **Builder and consumer interests are misaligned**
  Incentives for builders to construct at the lowest-cost are often not aligned with consumers' long-term economic interests or the nation's environmental and energy security.
- **Perverse incentives**
  Some electric utility rates and non-rate based financial incentives are designed to inhibit natural gas service installation and promote aggressive fuel switching away from gas.
- **Inconsistent approach to energy policy, codes and standards**
  Policymakers and consumers lack a holistic and comprehensive perspective of energy use. Many energy policies, regulations, and codes and standards developed using a site-based approach to energy measurement limit natural gas and its advantages. A full-fuel-cycle approach, which incorporates all upstream energy efficiencies and emissions, would acknowledge and leverage the advantages of the natural gas delivery system.

Despite the range of benefits of natural gas, many remain unrealized. Some consumers do not have access to natural gas because it is financially prohibitive for utilities to extend service to them without outside assistance. Consumers also tend to incur higher upfront costs when purchasing and installing natural gas appliances, thereby limiting natural gas as a consumer option, despite the cost-effectiveness of using the fuel over the long term.

Current policies also prove constraining. Some appliance and building codes and standards designed to improve energy efficiency actually do the opposite because they do not take into account the far superior efficiencies of the upstream natural gas delivery system. Rules and policies that ignore these upstream efficiencies can inhibit the use of natural gas applications through higher purchase and installation costs compared with other energy sources. And other constraints are less fair-market oriented. Electric utilities sometimes propose incentives to builders to forego natural gas equipment installations in new construction, or offer lower service rates to consumers in all-electric homes, further impeding natural gas market penetration.

To achieve the full potential of direct use means reversing the counterproductive trends and removing the barriers to customer access to natural gas. The potential benefits exist in the short and long term. Converting an inefficient household to natural gas heat can provide immediate savings today. But over longer periods, as the electric and natural gas systems evolve, the integration of natural gas appliances and distributed energy technologies into an advanced smart energy grid will offer new pathways to increase efficiency, achieve carbon reduction goals, and productively optimize our domestic energy resources. New policies should support goals oriented to the public good, but policies must also be good for customers, presenting them with the best available options that also support public policy goals.

POLICY RECOMMENDATIONS

- Develop and incorporate full-fuel-cycle analysis into energy policy, regulations, and energy efficiency metrics.
- Provide consumers with the best available information about comparable energy options through the use of enhanced appliance and equipment labeling.
- Encourage government agencies, state public utility commissions and utilities to jointly innovate policies and regulations that provide better alignment of costs and benefits over the life-cycle of consumer equipment.
- Research and development programs and investment focus should include natural gas delivery and end-use technology to fully maximize the value of natural gas resources.

The full report, Squeezing Every BTU, studies and details all of these issues. Its purpose is to explore the market and policy-related issues surrounding natural gas direct use, as well as how natural gas can be used to maximize economy-wide energy efficiency and reduce greenhouse gas emissions. The study aims to provide an overview of the key benefits and advantages of direct use, and describe the critical constraints that limit direct use as a consumer option and energy policy tool. The full report may be accessed at www.aga.org

AGA American Gas Association www.aga.org | www.truebluenaturalgas.org

American Gas Association

Squeezing Every BTU

Natural Gas Direct Use Opportunities and Challenges

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January 2012

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Contents

Executive Summary

Natural gas is a critical component of today's energy mix. In 2011, natural gas will be used in more than 70 million households and businesses, serving more than 40 percent of the direct energy needs of the nation's homes and buildings. Natural gas will fuel almost one quarter of electricity generation. Industry will rely on natural gas as fuel for manufacturing and as a feedstock to create fertilizers for use by farmers. It is environmentally superior to coal and petroleum, producing low pollution and half the greenhouse gas emissions of other fossil fuels, and provides the foundation to unlock the potential of renewable solar and wind energy. Natural gas is available and local. The vast abundance of North American gas holds the potential for more than 100 years of energy. Natural gas is domestic, abundant, and cost effective. It is central to the nation's energy future.

Direct-Use refers to natural gas consumed directly used in appliances for space conditioning, water heating, cooking, and clothes-drying. In contrast, some consumers use natural gas indirectly by consuming electricity generated with natural gas. However, generally the natural gas distribution system is considerably more efficient than electricity since it avoids the significant losses associated with electricity generation, transmission, and distribution, which amount to nearly half the energy used in homes and commercial businesses.

The direct use of natural gas provides a cost-effective and resource-efficient choice for consumers and offers one more option in the suite of greenhouse gas emissions reduction strategies. And direct use makes financial sense as a consumer fuel choice. A household with natural gas usually spends less on heating, cooking, and drying than one using any other fuel. A recent AGA analysis showed that a household with natural gas for these appliances on average spends almost 30 percent less than a household with all-electric appliances, and leads to 37 percent lower greenhouse gas emissions.[1]

Potential Benefits of Natural Gas Direct Use

- Lower consumer energy bills
- Increase productivity of energy supplies
- Reduce energy imports
- Fewer pollutants and greenhouse gas emissions
- Reduce new electric power requirements
- Provide enhanced domestic energy security
- Safe and reliable

[1] American Gas Association. "A Comparison of Energy Use, Operating Costs, and Carbon Dioxide Emissions of Home Appliances." 2009. http://www.aga.org/Kc/analyses-and-statistics/studies/demand/Documents/0910EA3.PDF

Despite the range of benefits, many remain unrealized. Some consumers do not have access to natural gas, and sometimes it is financially prohibitive for utilities to extend service to them without outside assistance. Consumers also tend to incur higher upfront costs when purchasing and installing natural gas appliances, thereby limiting natural gas as a consumer option, despite the cost-effectiveness of using the fuel over the long term.

Current policies also prove constraining. Some appliance and building codes and standards designed to improve energy efficiency may do the opposite because they do not take into account the far superior efficiencies of the upstream natural gas delivery system. Rules and policies that ignore these efficiencies can inhibit the use of natural gas applications through higher purchase and installation costs compared with other energy sources. And other constraints are less fair-market oriented. Electric utilities sometimes propose incentives to builders to forego natural gas equipment installations in new construction, or offer lower service rates to consumers in all-electric homes, further impeding natural gas market penetration.

Limits and Constraints on Natural Gas Direct Use

- Appliance first cost – Gas appliances and supporting equipment often incur higher installation and up-front costs compared to alternative fuel applications.
- Misaligned builder and consumer interests – Incentives for builders to construct at the lowest-cost are often not aligned with consumers' long-term economic interests or the nation's environmental and energy security.
- Perverse incentives – Electric utility service rates and non-rate based financial incentives designed to inhibit natural gas service installation and promote aggressive fuel switching away from gas.
- Inconsistent approach to energy policy, codes and standards – Policymakers and consumers lack a holistic and comprehensive perspective of energy use. Many energy policies, regulations, and codes and standards developed using a site-based approach to energy measurement limit natural gas and its advantages. A full-fuel-cycle approach, which incorporates all upstream energy efficiencies and emissions, would acknowledge and leverage the advantages of the natural gas delivery system.

To achieve the full potential of direct use means reversing the counterproductive trends and removing the barriers to customers to access natural gas. The potential benefits exist in the short and long term. Converting an inefficient household to natural gas heat can provide immediate savings today. Over longer periods, as the electric and natural gas systems evolve, the integration of natural gas appliances and distributed energy technologies into an advanced *smart energy* grid offers new pathways to increase efficiency, achieve carbon reduction goals, and optimize natural gas resources. New policies should support goals oriented to the public good, but policies must also be good for customers, presenting them with the best available options that also support public policy goals.

Policy Recommendations

- Develop and incorporate full-fuel-cycle analysis into energy policy, regulations, and energy efficiency metrics.
- Provide consumers with best available information on comparable energy options through the use of enhanced appliance and equipment labeling.
- Encourage government agencies, state public utility commissions and utilities to jointly innovate policies and regulations that provide better alignment of costs and benefits over the life cycle of consumer equipment.
- Research and development programs and investment focus should include natural gas delivery and end-use technology to fully maximize the value of natural gas resources.

There are ample and extensive opportunities for direct use of natural gas in the industrial and transportation sectors as well. This includes applications for combined-heat-and-power (CHP), distributed generation, and efficient industrial thermal processes like direct-fire water heating. These remain important options to consider in any comprehensive energy policy.

Squeezing Every BTU studies and details all of these issues. Its purpose is to explore the market and policy-related issues surrounding natural gas direct use, as well as how it can be used to maximize economy-wide energy efficiency and reduce greenhouse gas emissions. The study aims to provide an overview of the key benefits and advantages of direct use, and describes the critical constraints that limit direct use as a consumer option and energy policy tool.

1. Advantages of Direct Use

Summary

Natural gas—in particular natural gas used for direct consumption in homes and businesses for heating, cooking, and other applications—is a cost-effective and reliable fuel source with many benefits. Among the many benefits to society and consumers:

- Natural gas usually provides the lowest-cost fuel option for consumers.
- Natural gas provides one of the most efficient, lowest-carbon energy delivery pathways to consumers.
- To fully realize the environmental benefits of the direct use of natural gas requires a comprehensive assessment of appliance and fuel options based on a full-fuel-cycle analysis of energy consumption and environmental impact.
- There exists significant potential for natural gas to enhance efficiency and reduce emissions from homes and businesses, especially as a substitution fuel in homes that rely on electric resistance appliances for heat or hot water.
- Natural gas can enhance energy *security as a substitute* for fuel oil, especially in the Northeast.
- The abundance of North American shale gas bolsters domestic natural gas supplies, which stabilizes prices and is good for consumers.
- New end-use technologies such as distributed generation and combined-heat-and-power can help maximize the benefits of this resource and make significant contributions toward broader public goals of grid reliability, energy efficiency and emissions reductions.

1.1 Introduction

Natural gas offers energy, environmental and security benefits generally unmatched by competing fuels. Each year, natural gas passes through approximately 2.4 million miles of pipeline, 86 percent of which comprises smaller distribution mains and services that reach approximately 70 million customers nationwide. Utility companies, which install and maintain this distribution system, serve primarily residential and commercial consumers, and a smaller number of industrial entities. The *Energy Information Administration, EIA*, reported about 65 million residential and 5 million commercial gas utility customers in 2009, and 144,000 industrial or other customers. The focus of this paper will be on the residential and commercial sectors.

Direct use refers to natural gas consumed by appliances in these sectors, as opposed to using gas to generate electricity that is used by those same applications. Consumers in homes and businesses use natural gas mainly for thermal energy in four primary end uses: space heating, water heating, cooking, and clothes drying. A small amount of gas also serves natural gas space cooling in the commercial sector. The majority of gas, however, is used for space and water heating *load*, the energy requirements to serve the consumer's need. Approximately 95 percent of gas demand in the residential sector is tendered for space and water heating, and about 65 percent in the commercial sector. Natural gas serves about two-thirds of the energy requirements for these applications today.

Natural gas provides not only convenience and affordability, but also environmental benefits. Comprised primarily of methane, natural gas produces the lowest full-fuel-cycle greenhouse gas emissions of any combusted fossil fuel—this includes the higher global warming potential of methane and its impact on emissions. In addition, gas use results in significantly fewer pollutants, emitting none of the mercury and far fewer nitrogen and sulfur oxides that is found in other fuels. Natural gas is a readily abundant and domestically available resource, which helps ensure stable prices. About 90 percent of the natural gas consumed in the United States is domestically produced, a share that has been increasing in recent years as new shale resources are added to the natural gas reserve base. Almost all of the remainder is imported natural gas from Canada. When natural gas is used in lieu of petroleum products, it can reduces crude oil imports from overseas and helps strengthen the energy security of the United States. It is traded and distributed under an established and well-tested regulatory framework. Also, many gas technologies have proven reliable over a century of development, both those used for transmission and distribution through the pipeline network, and those used in end-use applications like electric generation and direct-thermal combustion.

Direct-use applications capitalize on these benefits, relying on a distribution system that, when evaluated along the entire energy value chain, delivers the most useful primary energy to the customer with the fewest system losses relative to other systems of energy delivery. Thus direct-use can help increase the productivity of the nation's energy supplies and increase economy-wide energy efficiency. Furthermore, fueling more homes and businesses directly with natural gas can help reduce new electric power requirements by easing demand on the electric power grid while reducing the need to construct expensive new electricity generating plants. Direct-use technology is here today and affordable. Policymakers and regulators should establish energy policies that acknowledge that the direct use of natural gas provides a key option to help realize cost-effective efficiency and emissions goals.

These advantages, and the relative merits of direct use of natural gas compared with competitive fuels, are highlighted in Table 1 (page 9). The table is designed to summarize the qualitative attributes of each fuel choice that are available to residential and commercial customers. Each row denotes an advantage or attribute of a given energy source; columns represent energy options, including distillate fuel oil, propane and electricity. Electricity is further subdivided by primary generation source: coal, coal with carbon capture and sequestration (CCS), solar/wind, a new nuclear plant, or a new gas plant (other primary sources such as biomass are not included due to the relatively small place in the market they currently occupy). A checkmark indicates where that fuel option offers a specific advantage.

Table 1
Natural Gas Direct Use Advantages to Other Fuels
Checkmark given for each advantage an energy source provides.

				Electricity (by Generation Fuel)				
	Direct Use Natural Gas	Heating Oil	Propane	Coal	Coal CCS	Solar / Wind	New Nuclear	New Gas
Cost effective	● +			●				●
Resource efficiency	● +					●	●	●
Resource availability	●			●	●	●	●	●
Enhances energy security	●			●	●	●	●	●
Lowers carbon emissions	●		●		●	●	●	●
Reliable / proven technology	●	●	●	●		●	●	●
Regulatory certainty	●	●	●					

*Coal CCS = a new coal plant with carbon capture and sequestration.

The following advantages denoted in Table 1 are discussed more in the subsequent sections of this report:

Cost effective – Natural gas is the most cost-effective home heating fuel available. Fuel oil and propane are tethered to crude oil prices, which continue to rise, and expenditures for electricity for heating purposes are greater than natural gas on average. More details can be found in Section 1.2.

Resource Efficiency – The combined efficiencies of the natural gas production, gathering, processing, transmission, and distribution systems are the highest of any fuel. When gas is delivered to homes and businesses, the source-to-site efficiency is three times greater than that of electricity, and higher still than propane and heating oil. The full-fuel-cycle efficiency, which includes the entirety of the energy value chain, displays significant efficiency advantages and lower greenhouse gas emissions relative to other energy sources. See Section 1.3.

Lowers Carbon Emissions – Households using natural gas for heating, cooking and drying applications emit the lowest greenhouse gas emissions of any fuel when evaluated on a full-fuel-cycle basis. More details in Section 1.4.

Resource Availability – The development of techniques to extract shale gas has transformed the North American natural gas resource base to one of increasingly abundance. When considering home fuels, the availability of the primary resources is important, as is the availability of generation capacity in the case of electricity. While oil remains abundant, it is not a domestic resource. Renewables are theoretically infinite in supply, and nuclear has no immediate fuel constraints, but higher levelized costs of energy restrict solar, wind and nuclear investments. In addition, new EPA regulations are expected to hinder development of new coal-fired power plants. Thus natural gas is more accessible than all of these resources. More details on the natural gas resource base are found in Section 1.5.

Reliable Here-Now Technology – All options should be considered as the nation's energy demand grows and emissions and climate-related targets are imposed. The potential for renewables, nuclear and other forms of energy to meet these goals is significant. However uncertainties and costs associated with these must be weighed against the availability of natural gas and its direct use as a tool to also serve the nation's growing energy needs, while adhering to environmental goals. See Section 1.6 for more.

Enhances Energy Security – Natural gas has the potential to replace petroleum-based fuels with a domestically produced energy resource. The fuel oil market represents one of these opportunities. For more see Section 1.7.

The purpose of Table 1 and the following subsections is to provide a general picture of the various attributes offered by each consumer fuel option. Some of these advantages, of course, are dependent on local and regional factors; relative fuel benefits vary by geography. Regional differences in fuel prices and the electric generation mix changes the relative advantages, sometimes away from natural gas. An electric system with a less carbon-intensive generation mix—such as in the hydroelectric-intensive Northwest—means that natural gas may not always be the preferred solution for greenhouse emissions reductions. However, natural gas has a cost advantage in many regions for most applications, and proves far superior as a greenhouse gas reduction tool in many areas. These variations should be acknowledged and embraced as part of any reasonable energy policy.

The following subsections describe in more detail the relative advantages of natural gas and direct-use applications.

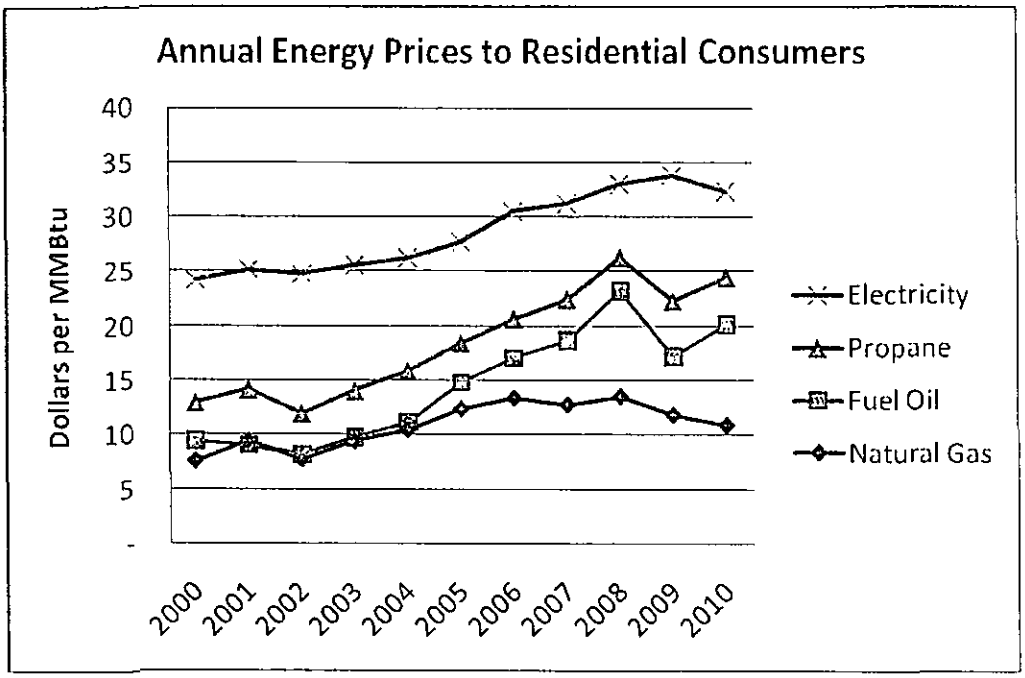
1.2 Cost Effective Fuel Option

Currently, the price of natural gas is the lowest of the four principal energy options available to residential and commercial consumers. According to an analysis by the American Gas Association, using natural gas can save homeowners 30 to 45 percent on their energy bills. This section describes the changes in delivered fuel prices during the last decade, including today's prices, and presents a comparative analysis of homeowner utility bills for a typical new household using the four principal fuel types available.[1]

The cost of all energy forms has risen during the last 10 years. Electricity prices have steadily increased, and propane and fuel oil have shown marked cost increases over the same period. Natural gas has also increased and has been subject to the same volatility that befell many commodities during the run-up and subsequent crash in commodity prices during 2008. Figure 1 illustrates the changes in prices for these fuels over the last decade, and highlights the relative stability and low price of natural gas relative to the other fuel options.

- *Electricity* has traditionally been the highest cost energy source on an energy equivalent basis. The average price for electricity delivered to homes was $32.33 per million British Thermal Units (MMBtu) in 2010, rising 34 percent since 2000.
- *Fuel oil*, which is linked to crude oil prices, had an average price of $20.15 per MMBtu in 2010, rising 113 percent since 2000.
- *Propane*, which is also linked to crude oil but to a lesser extent natural gas prices as well, had an average cost of $24.43 per MMBtu in 2010, rising 90 percent since 2000.
- *Natural gas* has the lowest cost per unit energy of the fuels presented here. Natural gas costs residential customers $10.90 per MMBtu, rising 44 percent since 2000.

Figure 1
Natural Gas Remains the Least Cost Fuel for Consumers



Source: EIA

What do these energy prices mean for consumer energy bills? Consumers will use different amounts of energy depending on their energy source and the number of appliances installed. To estimate the impact prices have on consumer energy bills, AGA conducted an analysis of the energy profile of a typical new home with space heating, water heating, cooking, and clothes drying, using each of the four fuels above. The site-based consumption estimates for the appliances, all of which were assumed to meet the federal minimum efficiency standard, were then multiplied by the fuel's average energy price in 2010 to estimate consumer expenditures per year for those applications. The final expenditures for these end uses in a typical home are listed in Table 2.[ii]

To summarize the results of the study:

- The annual site-energy requirement is 107 MMBtu per year for and average natural gas and propane household, 109 MMBtu for an average fuel oil household, 53 MMBtu for the average all-electricity household (with an air-source heat pump).
- The average natural gas household spends $1,275 per year for fueling these appliances.
- An electricity household incurs, on average, $1,793 in expenditures for an electric heat pump, resistance water heater, cooktop and stove, and dryer. The expenditures are 40 percent higher than the natural gas household.
- A fuel oil household spends $2,252 operating a furnace and water heater. Cooking and clothes drying are assumed to be electric. These expenditures are 77 percent higher than natural gas. [iii]
- *Consumers with propane spend on* average $2,596, which is 103 percent greater than a natural gas household.

Table 2: Estimated Annual Energy Bill for Typical New Household (2010$)

	Natural Gas	Electricity	Oil	Propane
Space Heating	$887	$1,062	$1,542	$1,806
Other	$388	$731	$710	$790
Total	$1,275	$1,793	$2,252	$2,596

For space heating, water heating, cooking, and drying applications.

For more details on the study and the assumptions made for each household, the full report can be accessed at:
http://www.aga.org/SiteCollectionDocuments/ResearchStats/Studies/Consumers%20n%20Demand/0910EA3.PDF

Regional price differences can change the relative benefits of natural gas compared with other fuel options. But natural gas out performs electricity and other energy options in most areas of the country. That said, appliance first-cost issues can prevent consumers from realizing the low-cost benefits of natural gas. The purchase and installation of a natural gas furnace and water heater is typically more expensive than an electric counterpart. This constraint is discussed in more depth in Section 2.2 on page 31.

1.3 Greater Resource Efficiency

Energy efficiency remains one the easiest and most effective ways to reduce energy consumption and mitigate greenhouse gas emissions. Of the various forms of energy available to residential and commercial consumers, the natural gas distribution system remains one of the most energy efficient. That is, the energy required to produce, process, transport, and distribute usable energy is less along the natural gas distribution system compared with other energy options, including electricity. This is called *source-to-site* energy consumption or efficiency. When the upstream energy consumption is combined with the energy consumed at the point of use, the higher *full-fuel-cycle* energy efficiency of natural gas makes it a superior choice for energy and emissions reductions. When energy usage is viewed using this holistic, comprehensive approach, the relative efficiencies of the natural gas distribution system stand out relative to other forms of energy. Once these efficiencies are considered, the substitution of gas for less efficient forms of energy – in particular, electric resistance heat – can help achieve environmental and energy efficiency goals.

The following subsections describe the energy value chain of natural gas, electricity, fuel oil, and propane, and present a case for why a full-fuel-cycle approach is necessary to fully realize the potential for energy and emissions reductions. The full-fuel-cycle discussion is followed by a subsection on electric system losses, quantifying the amount of energy lost to waste heat from the production and delivery of electric energy. Finally, the last subsection describes how direct use may be one method for mitigating some of these losses as well as promoting the reduction of electric resistance heating, one of the most inefficient uses of electricity when evaluated along the *full-fuel-cycle*.

1.3.1 Energy Value Chain Efficiencies and the Full Fuel Cycle

The energy value chain is the process by which an energy source is produced and delivered to consumers. While each fuel has a unique value chain, there are many common elements. The energy value chain can be divided into six stages:

- Fuel extraction
- Processing
- Transportation
- Conversion
- Distribution (including electric long-distance transmission)
- End-use

Through the analysis of a given fuel's energy value chain, we can better understand the energy consumed and the emissions from our energy choices. Each stage for each fuel has a unique physical process associated with it, and the energy efficiencies associated with this process can vary even within an industry. The physical extraction of coal from the ground might vary depending on the type of coal mined, where it is mined, and the distance the coal must travel until it is consumed. The same is true of natural gas; differences between conventional and unconventional gas production, distance to market, and varying geologies affect each of these stages. The efficiencies listed in this report consider these differences and reflect aggregated industry averages.

Defining Measures of Energy Consumption

Site (point-of-use) measure of energy consumption reflects the use of electricity, natural gas, propane, and/or fuel oil by an appliance at the site where the appliance is operated, based on specified test procedures.

Full-fuel-cycle measure of energy consumption includes, in addition to site energy use, the energy consumed in the extraction, processing, and transport of primary fuels such as coal, oil, and natural gas; energy losses in thermal combustion in power-generation plants; and energy losses in transmission and distribution to homes and commercial buildings.

Source: National Academy of Science

Table 3 details the individual efficiencies of each stage of the energy value chain. Each percentage represents the proportion of usable fuel exiting that stage. For example, natural gas processing is assigned a value of 96.9 percent. That is, for every 1,000 methane molecules entering this stage, 969 molecules move into transportation. The remaining 31 molecules (or 3.1 percent) are lost as fuel consumed or inefficiencies in the system. The cumulative efficiency represents the total energy delivered to the consumer prior to end use. The exact value of this, denoted in the last column of the table, is the product of the efficiencies from each preceding value chain stage.

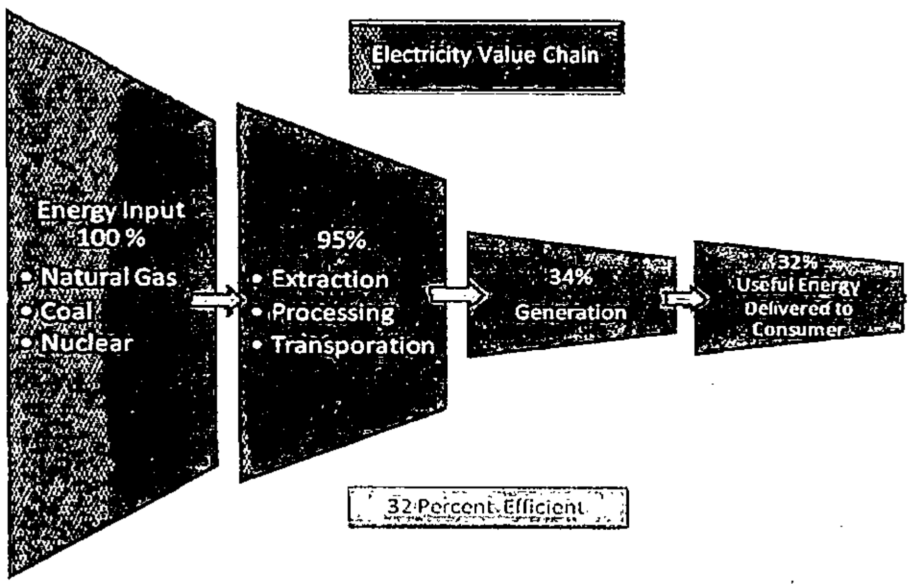
Table 3: Energy Value Chain Efficiencies

Value Chain:	Extraction	Processing	Transportation2	Conversion	Distribution	Cumulative Efficiency
Natural Gas	97.0%	96.9%	99.0%	--	98.8%	**91.9%**
Oil	96.3%	93.8%	98.8%	--	99.3%	**88.6%**
Propane	95.9%	95.3%	98.6%	--	99.2%	**89.3%**
Electricity:						
Coal-Based	98.0%	98.6%	99.0%	32.7%	93.8%	**29.3%**
Oil-Based	96.3%	93.8%	98.8%	31.7%	93.8%	**26.5%**
Natural Gas-Based	97.0%	96.9%	99.0%	42.1%	93.8%	**36.7%**
Nuclear-Based	99.0%	96.2%	99.9%	32.7%	93.8%	**29.2%**
Other[3]-Based	--	--	--	56.0%	93.8%	**49.7%**
Electricity Weighted Average[4]	--	--	--	35.8%	--	**31.9%**

Source: Gas Technology Institute

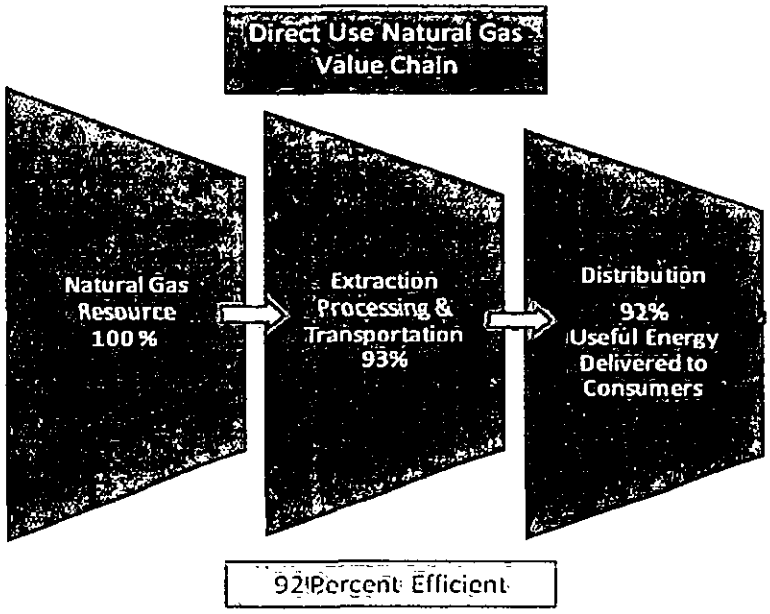
The electricity sector, on aggregate, produces and delivers energy to consumers along a value chain with the greatest inefficiencies. As Table 3 indicates, most electric system losses occur during the conversion (generation) stage, where a primary fuel is used to power electromechanical generators. Electricity is then generated and the excess heat energy not utilized for work is discarded. The efficiencies at this stage vary depending on the type of turbine and fuels utilized. Conventional steam turbines powered by coal or nuclear typically operate within a heat rate efficiency range between 32 and 33 percent; advanced combustion turbines may reach efficiencies of 37 percent. Natural gas advanced combined-cycle turbines, which use a combination gas turbine engine connected to a steam turbine, can achieve efficiencies greater than 50 percent. Renewables like wind and solar have no primary energy conversion losses. The average conversion efficiency used in this analysis is aggregated based on the average mix of fuels in the nation's electricity generation portfolio. When the efficiencies from the electricity value chain are aggregated and weighted by share of U.S. generation mix, an "average" efficiency of 32 percent is assigned to the electricity sector. That is, on average only one third of all energy used to generate and transmit electricity is actually delivered to the end-use consumer.

Figure 2 Electricity Source-to-Site Economy Wide Average Efficiency



The natural gas distribution system, by contrast, has significantly fewer energy losses. Natural gas delivered directly to consumers is a much more efficient energy delivery system, with significant implications for efficiency, economics and the environment. As a result, direct-use may be a more attractive option than electricity for direct-heating applications; natural gas use in homes and business could offset electricity usage and new generation requirements, while reducing emissions, saving energy, and optimizing energy resources. Again, this relies on an accurate, economy-wide measurement of energy consumption and environmental impacts and a comprehensive evaluation of energy impacts. A full-fuel-cycle approach is one such methodology.

Figure 3: Natural Gas Source-to-Site Economy Wide Average Efficiency



The full-fuel-cycle methodology provides a more complete picture of energy impacts. Consider electric heat. An air-source heat pump may often achieve site efficiencies more than 300 percent; heat pumps achieve these plus-100 percent efficiencies because they *move* heat from a colder environment to a warmer one, instead of directly warming the air, and therefore are unburdened by fuel-combustion related energy loss. By itself, a heat pump presents consumers with an attractive option: a heat pump operating at 300 percent efficiency seems more appealing than a natural gas furnace at 90 percent. However, this efficiency ignores upstream energy losses. When the full-fuel-cycle efficiencies are aggregated, the electric system efficiency on average operates around 32 percent prior to use. This changes the equation and comparison between fuel types. A minimally rated electric air-source heat pump operates at a 79 percent full-fuel-cycle efficiency, not 225 percent, for a minimally rated 7.7 HSPF air-source heat pump. In comparison, natural gas furnaces operate at a 72 to 88 percent full-fuel-cycle efficiency.

Table 4 summarizes the average energy usage per year for a new household for space heating, water heating, cooking and clothes drying (data from the same AGA analysis referenced earlier).[2] Site and full-fuel-cycle efficiencies are included. The results show that natural gas operates with higher full-fuel cycle efficiencies than any other major consumer fuel source. Natural gas use in primary residential appliance applications uses 121 MMBtu per year on a full-fuel-cycle basis. Electricity by contrast uses 167 MMBtu per year when measured on a full-fuel-cycle basis, despite having site-energy consumption that is more efficient than natural gas. Both oil and propane for the same applications were higher than natural gas, 136.3 and 124.5 MMBtu respectively.

[2] The study assumes that electric applications are used for cooking and clothes drying within fuel oil households.

Table 4: Average Household Energy Usage per Year for a New Household (MMBtu)

	Natural Gas	Electricity	Oil	Propane
Space Heating	74.3	31.5	74.3	74.3
Water Heating	25.4	16.6	29.1	25.4
Cooking	3.3	1.8	1.8	3.3
Clothes Drying	3.8	3.3	3.3	3.8
Total Site Use	**106.9**	**53.2**	**108.5**	**106.9**
energy losses	14.1	113.5	27.8	17.6
Full-Fuel-Cycle Use	**121.0**	**166.7**	**136.3**	**124.5**

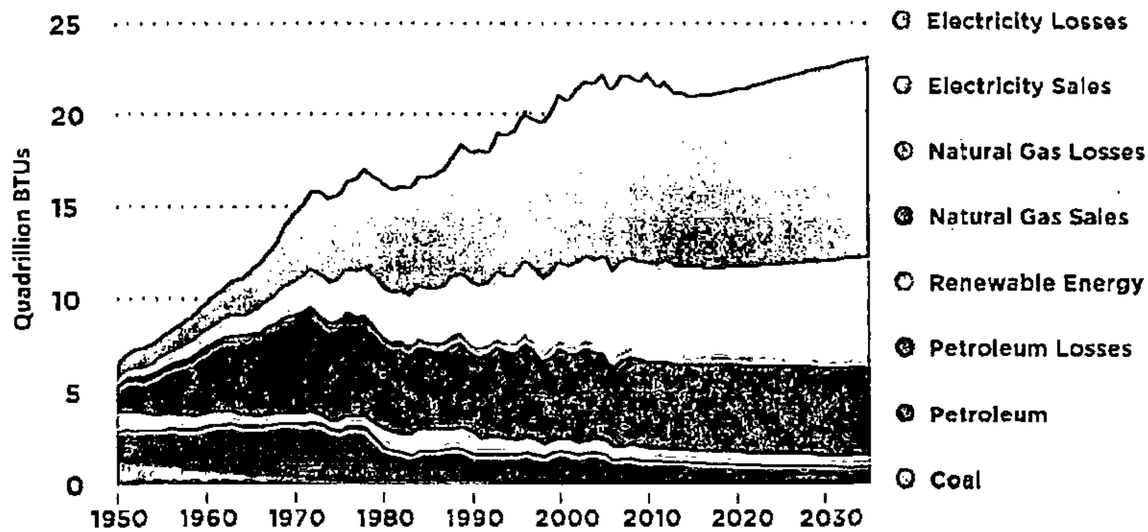
Losses include energy used or lost in extraction, processing, conversion, transportation, and distribution of energy
Full-fuel-cycle is sum of site use and energy losses

In sum, the full-fuel-cycle method of measuring energy usage across the energy value chain is the most comprehensive and accurate way of determining a fuel source's total energy and environmental footprint. Such a measurement conclusively demonstrates the benefits of the direct use of natural gas, but it has larger applications. In terms of optimizing available energy resources, considering strategic energy decisions, and formulating national policies and regulations that will actually increase energy efficiency and reduce emissions, a full-fuel-cycle methodology must be incorporated. What is more, to the extent that building energy codes and standards, appliance standards and labeling, and home and building energy rating systems are based on the full-fuel-cycle measurement, energy efficiencies and emissions reductions will improve even more significantly.

1.3.2 Mitigating Electrical System Losses

Nearly all of the growth in energy usage in the residential and commercial sectors during the last three decades is due to increased electricity consumption. New electric appliances and devices have driven this growth, despite improvements to appliance, equipment, and building shell efficiencies. New demand drives greater electricity sales, in turn engendering greater electrical system losses. As described in the last section, due to electricity generation and transmission nearly two-thirds of the primary energy in the electric system is lost to waste heat. The share of electric waste heat has grown to a sizeable portion of total energy consumed. When compared alongside other energy forms, electric system losses today now represent *half* of all energy used in the residential and commercial sectors.

Figure 4
Residential Sector Energy Consumption



Source: U.S. Energy Information Administration (EIA)
*Electricity losses refer to electrical system losses including heat lost to generation, transmission, and distribution.
*Coal and petroleum losses approximately account for less than 1% of total energy consumption

Today electrical system losses represent the single largest share of energy consumption in the residential and commercial sectors. To illustrate, Figure 4 shows residential energy consumption by primary fuel and electricity, including losses. In the chart, data from 1950 to 2009 are based on historical data reported in the EIA *Annual Energy Review*; projections for the years 2010 through 2035 rely on the EIA Annual Energy Outlook (AEO) 2011 Reference Case scenario. When aggregated, the change in residential energy consumption is telling.

Forty years ago, in 1970, electricity sales represented 11 percent of all the energy consumed in the residential sector, and electrical system losses accounted for about 26 percent. By 2010, electricity sales doubled to 22 percent and electrical system losses grew to 47 percent. This growth trend in electricity sales—and losses—is projected to continue. The AEO 2011 projects total electricity consumption is to grow at nearly 1 percent per year from now until 2035, growth driven by the myriad electronic devices available to consumers: televisions, audio players, microwaves, toaster ovens, coffee makers, computer speakers, air purifiers, battery chargers, vacuum cleaners, and so on.[iv] Meanwhile, natural gas consumption grew until 1970 and has since remained flat. Few major new natural gas appliances have been introduced into the market, or are expected too, and existing natural gas equipment has become more efficient over time. Consumption has remained flat, and the AEO projects this horizontal trend out through 2035.

There is significant opportunity for direct use to help stem some of this electric energy growth and, consequently, mitigate electric system losses. Electric resistance heating is one of the most inefficient energy technologies available and is prevalent in the home heating market today. It is also one of the least expensive, particularly on a first-cost basis. Thus, home builders and buyers focused on initial cost are often pushed toward this lower efficiency, higher emitting option. Alternatively, the direct-use of natural gas in lieu of older electric furnaces and resistance water heaters can help to avoid electric system losses, lower greenhouse gas emission, and increase overall energy resource efficiency.

About 20 percent of residential electric sales are used for space heating, water heating, cooking and clothes drying applications; in 2010 these end-uses used 1,020 trillion BTUs of electricity. But this is only part of the full energy picture. The waste heat associated with electric generation and transmission was twice as high: 2,175 trillion BTU in 2010. The total primary energy consumed was 3,195 trillion BTU.[v] There is a diverse set of appliances that serve these applications, including appliances that rely on electric resistance. It is within these resistance applications that we find significant potential for energy efficiency improvements.

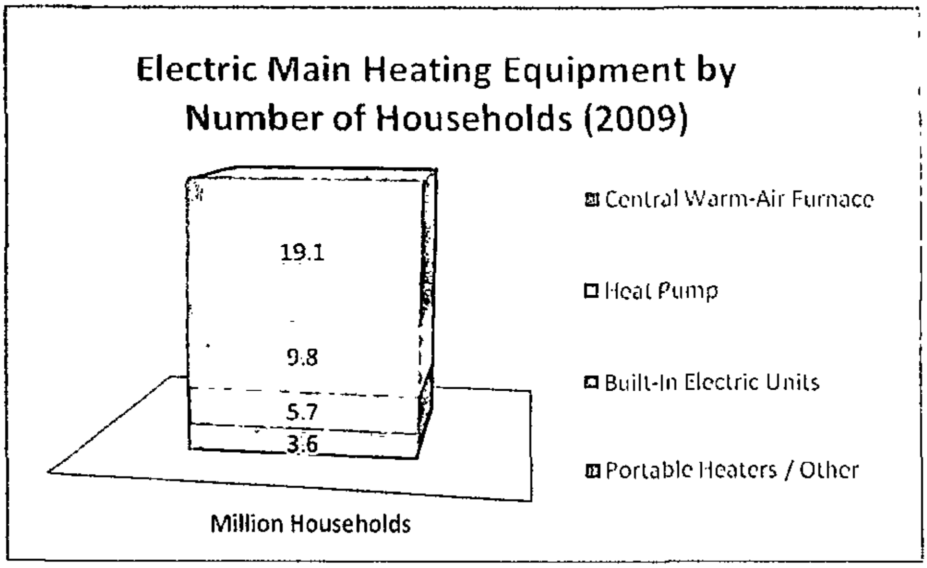
1.3.3 Low-Hanging Fruit for the Gas Industry - Electric Resistance

Electric resistance heating represents one of the least efficient forms of space and water heating, as measured on a full-fuel-cycle basis. Most electric heating relies on a resistance heating element: coiled wires acting as resistors that convert electrical current into heat. Most electric space heating appliances or equipment, such as furnaces and baseboard heaters, use a resistance heating element, although there are many air-source heat pumps on the market today as well, which are significantly more efficient than resistance furnaces and baseboard heating. Electric water heaters almost universally rely on electric resistance as the primary heating element.

Strictly speaking, from the perspective of household energy consumption, resistance heat is an efficient use of electric energy. Electric furnace and water heater efficiencies can approach nearly 100 percent, as nearly all the electric energy is converted to usable heat. Technology has maxed out any possible efficiency gains. Upgrading resistance heaters will offer only marginal efficiency gains, if any. Better insulation around the furnace, piping, or heating ducts can make incremental gains in efficiencies; however, this class of technology is fundamentally limited in terms of energy efficiency improvements. New options are needed instead. A heat pump offers significantly higher efficiencies, and for many consumers this option is viable and cost effective. And when the full-fuel-cycle measurement is considered, natural gas furnaces also offer marked improvements in energy efficiency.

The size of the electric resistance heating market is substantial. About 38 million households in 2009 used electricity for space heating, and about half of these residences utilize resistance furnaces. For water heating, about 45 million households used electricity; resistance water heaters are ubiquitous in this market.[vi] Within the commercial sector, approximately 1.2 million buildings (32 percent) use electricity for primary space heating, and one quarter of these report using resistance furnaces, according to a 2003 survey. Approximately 1.9 million buildings (55 percent) use electricity for water heating in the same survey.[vii]

Figure 5: About half of all electric home use electric resistance furnaces for space heating.

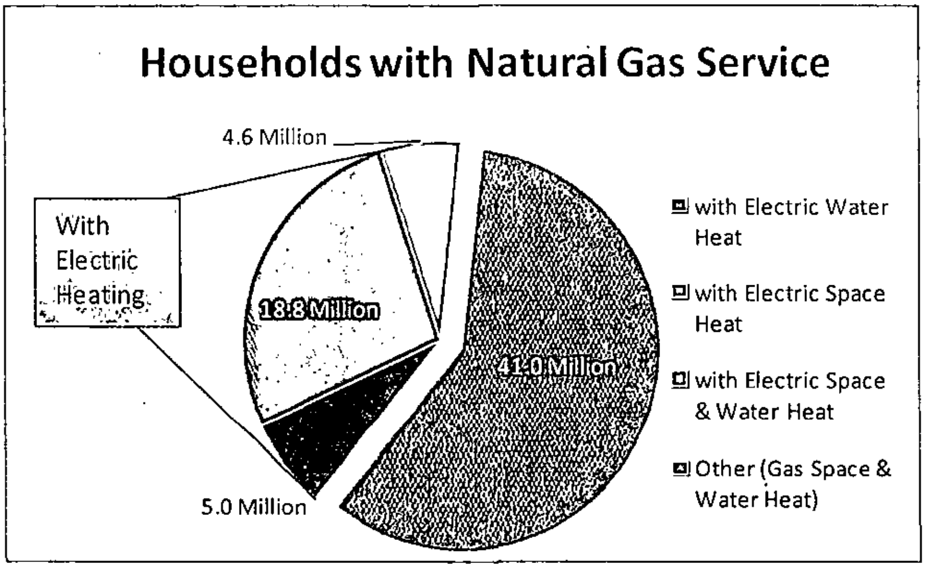


Source: EIA

Direct use of natural gas is both an energy solution for many of these consumers and a means toward efficiency and emissions improvements. The substitution of electric resistance space and water heating appliances and equipment with direct-use natural gas counterparts can improve energy efficiency, reduce greenhouse gas emissions, and decrease customer energy bills. However, conversion of these households and buildings is difficult. The first cost of natural gas appliances and the build out of supporting infrastructure may be prohibitively expensive. Furthermore, consumers might resist the notion of changing primary fuels in their household, in part because conversions can be difficult. Or perhaps they have a preference for electricity. Whatever the case, conversion opportunities are likely limited in all-electric markets.

However, there are many households and buildings with natural gas service that instead use electric resistance heaters for space and water conditioning. These households, for instance, may have an electric resistance water heater, but a natural gas furnace for space heating. Many conditions that would limit potential conversions, such as resistance to gas or costs for infrastructure build-out, do not apply here. Therefore, customers *with gas service* but electric equipment represent the *low-hanging fruit* of efficiency improvement opportunities. Installing natural gas service in a household must be economically feasible for a utility, so a household or building with existing gas service reduces the upfront costs of installing a new natural gas appliance. These customers are also likely to have a familiarity with natural gas, both as a fuel enjoyed, but also because of a consumer relationship with their local distribution utility. These points of leverage can help expand and accelerate natural gas conversion potential.

Figure 6: Approximately forty percent of households with natural gas service use electricity for space or water heating.

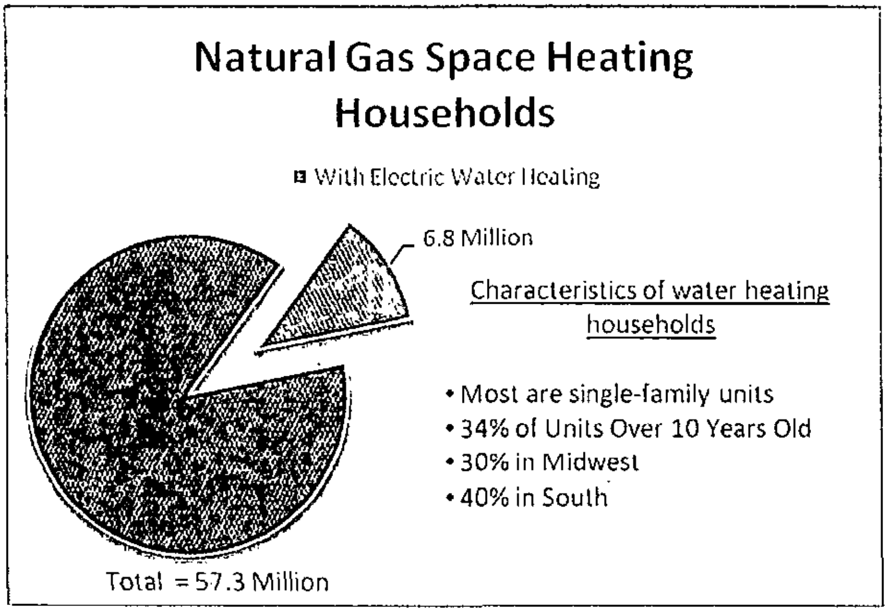


Source: EIA RECS 2009

Nearly 70 million households enjoy natural gas service in the United States. However, a significant portion does not use natural gas for their primary heating applications. In 2009, according to the most recent data collected as part of the Energy Information Administration "Residential Energy Consumption Survey", about 28 million or 40 percent of households with natural gas service instead use electricity for space heating, water heating, or both (see Figure 6). These households may use natural gas for cooking, for example, but have opted instead for an electric appliance for their heating needs. And this snapshot follows a trend of increasing numbers of electric heating appliances in gas households. The same dataset shows that the number of gas households with electric heating increased 4 million since 2005 (24 million to 28 million), despite the total number of gas customers are staying relatively constant. A closer look at the data indicates that while households with natural gas service have adopted both electric space and water heating applications over this period, much of increase was in electric space heating applications.

The most likely conversion opportunities are natural gas consumers who also use energy intensive electric resistance equipment. The prime example would be households with natural gas space heating *and* electric water heating. Based on the most recent EIA RECS data from 2009, approximately 57 million households use natural gas as their main space heating fuel. A significant portion use an electric resistance water heater, about 12 percent or 6.7 million households (this is up from 6.2 million or 11 percent of total households with natural gas main space heating in 2005).[viii] Gas service is already present to serve a gas furnace or boiler, so proper piping and adequate ventilation equipment are more likely to have been installed, thereby lowering conversion costs. Substituting an electric resistance water heater for a gas storage or tankless model would lower total energy used and could decrease greenhouse gas emissions. Furthermore, and probably most important, customers would decrease their water heating bill by half.[ix]

Figure 7



Source: EIA RECS 2009

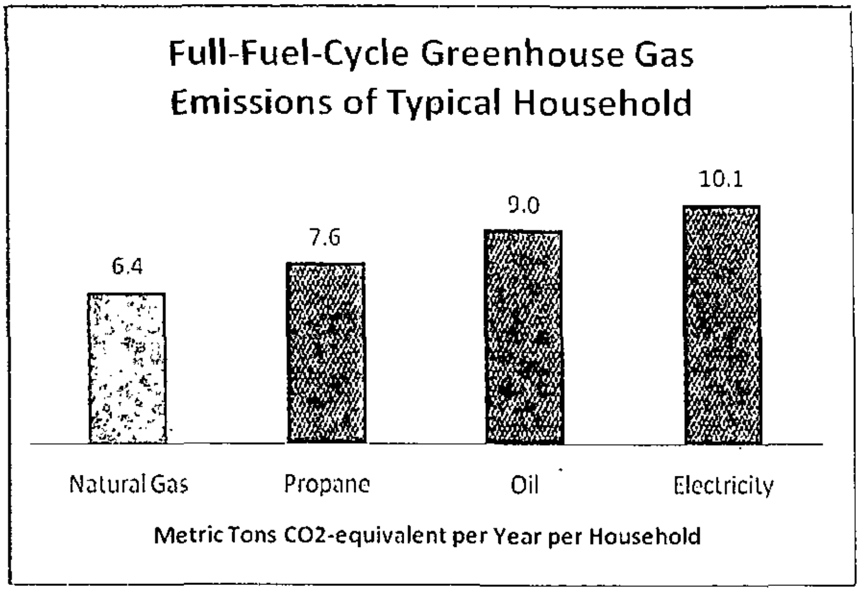
More information about appliance installation and operation costs can be found in Section 2.2.

Natural gas direct-use applications offer a pathway toward enhancing energy resources and circumventing electricity losses. There are many households and businesses with aging HVAC and water heating equipment that should be upgraded to more efficient equipment where possible. And in those instances in which natural gas is installed as the replacement fuel, the energy savings and emissions-reduction potential are significant. Efficiency programs, incentives, policies and regulations designed to reduce energy and greenhouse gas emissions should consider the amount of energy lost to electric system losses and the potential for direct use to mitigate these losses.

1.4 Reduce Environmental Impacts

Mitigating greenhouse gas emissions and reducing pollutant emissions remain salient policy issues in today's political sphere, and both can be achieved by using natural gas directly in households and businesses instead of other fossil fuels. Natural gas produces the fewest greenhouse gas lifecycle emissions of any available fossil fuel, while also producing very low levels of sulfur dioxides, nitrogen oxides, and fine particulate matter—and no emissions of mercury.

Figure 8



Source: AGA

The relative greenhouse gas intensities for a typical household in a year were estimated in the AGA paper, "A Comparison of Energy Use, Operating Costs, and Carbon Dioxide Emissions of Home Appliances," and are illustrated in Figure 8. Based on that paper, the average full-fuel-cycle greenhouse gas emissions of a typical natural gas household's energy use is 44 percent less than the equivalent energy from electricity. This includes combusted and fugitive or leaked methane emissions. Similarly, the natural gas household modeled emitted 27 percent less greenhouse gases than a household using distillate fuel oil, and 16 percent less than one using propane.

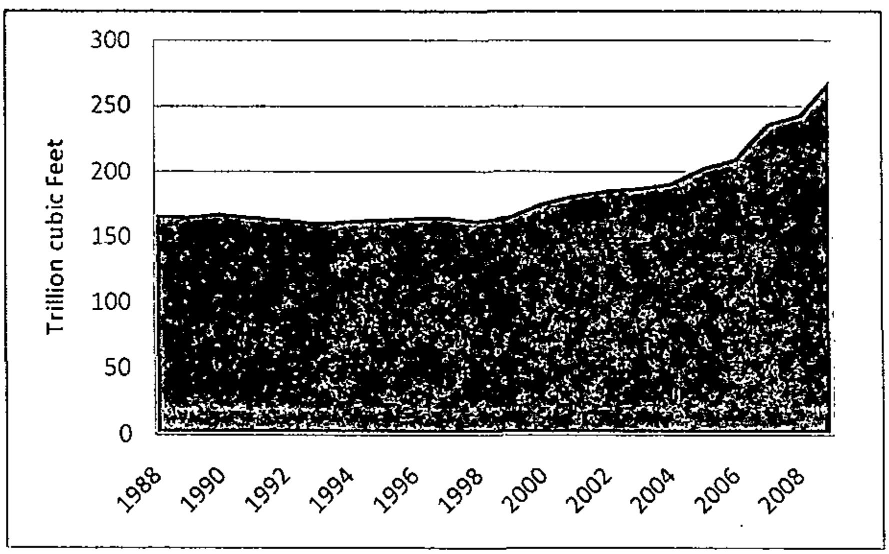
It is also important to note that the costs associated with these emissions reductions are commensurably less compared to other carbon mitigation alternatives. A study by McKinsey & Company in 2007 found that the installation of high-efficiency appliances generates a return on investment for the carbon mitigation achieved. In McKinsey's model, new and retrofitted HVAC systems in homes, when combined with a move toward natural gas and away from carbon intensive electricity and fuel oil, resulted in a negative cost (positive benefit) per ton of carbon reduction achieved. The study notes that HVAC accounts for 34 percent of residential GHG emissions annually, or 600 megatons, and represents 19 percent (360 megatons) in the commercial sector. The study elaborates on the mitigation potential: "installing more efficient HVAC systems and improving building shells could abate 160 megatons of CO_2 per year by 2030." In addition to efficiency improvements, the study notes that "switching from [liquefied petroleum gases] or fuel oil to natural gas, which burns more efficiently, could abate 12 megatons annually by 2030, with two-thirds of the amount in the Northeast." In the commercial sector, the McKinsey model calculates a 45 megaton abatement potential; switching to natural gas represents a 7-megaton abatement opportunity if substituted for fuel oil or LPG.[x] Therefore, not only is there significant carbon savings potential, but also these strategies can be pursued with a net economic benefit to consumers.

1.5 Abundant, Domestic Supply of Fuel

Natural gas today is a widely available, increasingly abundant, domestically produced fuel. Technical innovation has opened access to unconventional resources like coal seams, tight sands, and shale formations. Advances in production are lowering costs, making once previously uneconomical or inaccessible sources now profitable to producers and available to consumers at stable, affordable prices. Furthermore, new supplies and a reliable supply portfolio – which includes domestic production, gas in underground storage, imports from Canada, and liquefied natural gas – help keep prices stable during times of peak demand.

The exploration and production of natural gas has accelerated rapidly over the last five years, and the recoverable gas resource base has grown tremendously. Proved domestic reserves are now at the highest levels in 40 years and outlooks suggest more than 100 years of available natural gas supply at today's production levels. There still exist many questions and concerns over the environmental impacts of procedures to access these unconventional resources, in particular the hydraulic fracturing process. However, the fact remains that there is an abundant energy source that can play a key role in the nation's energy mix well into the future.

Table 5: Domestic Dry Gas Reserves



Source: EIA

The extent of the new resources is significant. The *Energy Information Administration* (EIA) released new estimates of the available natural gas resource base in the United States for year-end 2009. The results show a tremendous increase in available gas reserves, up 11 percent since the previous year and the highest levels since 1971. The technically recoverable volumes of gas increased more than 500 Tcf in one year—to 2,620 Tcf in 2009. Shale development is the driving force behind this substantial growth, although some growth came from conventional onshore and tight sands production as well.

U.S. marketed production of natural gas has been steadily increasing, largely because of the development of shale. Over the past year alone, domestic daily dry gas production has grown about 7 percent to 60 Bcf per day. In 2000 shale gas share of production was virtually zero. Today, shale accounts for 25 percent of gas produced in the United States and in its "2011 Annual Energy Outlook", EIA projects shale gas comprising 46 percent of all natural gas production by 2035.

This growth will help support new demand expected during the next few years and over the coming decades. Shale gas development can enable the use of natural gas for electricity generation, as a transportation fuel, and as a direct fuel in homes and businesses. The safe and environmentally sound production of this resource can enable long-term access and use of domestically produced natural gas.

1.6 Available Here and Now

The energy landscape today is fraught with uncertainty. Electricity markets, investors, utilities, and regulators see a disjointed and unclear energy policy pathway that has delayed long-term investment in new electric generation capacity. Many nuclear power plants are inching closer to retirement and for environmental reasons coal-fired power plants are not being built, yet consumer demand for electricity continues to grow. That means new generation capacity will have to be installed over the coming years and the nature of new electric generation capacity will be determined by a number of uncertain factors. In this context, the direct use of natural gas offers a "Here-Now-Available" cost-effective solution to help ease electric load requirements and reduce the need for new generation capacity.

Table 6

Cumulative Unplanned Electric Generation Capacity Additions and Costs (by 2035)
(Gigawatts installed)

	Current Policies /1	Carbon Constrained Policies /2	Total Overnight Cost in 2009 (2008 $/kWh)
Nuclear	6.3	62.0	$3,820
Gas Combined Cycle	60.9	54.7	$648

1/ - EIA Annual Energy Outlook 2011 Reference Case
2/ EIA Analysis of American Power Act 2010.

For instance, there are concerns about the impact upcoming EPA regulations on the electricity sector will have on electricity costs and grid reliability; however the full details about the regulations and implementation dates are not yet established so the potential impacts are still hard to gauge. Another factor shaping energy decisions is the possibility of a greenhouse gas reduction regime, its possible reach, and whether EPA is tasked with regulating carbon dioxide emissions from power plants. Or Congress could develop an alternative scenario in which it mandated a broader "Clean Energy

Standard," which, in addition to renewables, could include nuclear and natural gas as compliance options for meeting less carbon-intensive electric generation.

The high cost of installing new capacity and the uncertainty surrounding these costs present additional challenges. Table 6 shows the unplanned electric generation capacity additions and the total overnight cost for a new nuclear plant and a natural gas combined-cycle plant. Two possible cost scenarios are also shown, one for business as usual and another assuming a carbon policy.

The first column represents current governmental policies as reflected in the Annual Energy Outlook 2011 reference case. Natural gas combined-cycle generation capacity is projected to grow 1.2 percent per year. The total overnight costs for nuclear averages $3,820/kWh.[3] Gas combined-cycle technology is the least expensive electricity option available at $648/kWh.

The second EIA scenario illustrates the effects of a carbon constraining policy on the economy by assuming passage of the American Power Act of 2010 (APA 2010), which was designed to regulate greenhouse emissions through a market-based regime.[xi] The result of the carbon price modeled in this scenario, unsurprisingly, was a significant increase in less carbon-intensive electricity generation capacity: renewable and nuclear power generation capacity additions increase 1.3 percent per year and 0.4 percent per year respectively from 2008 to 2035. This in turn pushes up costs overall for new generation capacity.

The direct use of natural gas offers a cost-effective solution to ease electric capacity constraints and reduce the need for new generation capacity. For example, replacing electric resistance water heaters with natural gas water heaters could help regulators to achieve energy efficiency and demand-side management goals.

Some states are already leading the way with policies to utilize natural gas water and space heating applications to enhance energy efficiency and conservation programs. Pennsylvania offers one example. The state public utility commission has considered using fuel switching as a cost-effective tool to reduce electricity demand. In 2008, the state legislature passed and the governor signed into law Act 129, which set forth goals for reducing energy consumption and demand.[xii] The legislation amended the state Public Utility Code to require the implementation of an energy efficiency and conservation program. One component of this program would incentivize electric customers to switch to natural gas in order to reduce the electric system constraints and lower costs. A working group that convened to discuss and study fuel switching programs recommended to the PUC that fuel switching, while it shouldn't be mandated, should be made available to electric distribution companies and their stakeholders when considering the best means of achieving energy efficiency and conservation goals. At least one utility has begun taking advantage of this program by offering rebates to electric customers to incent switching to natural gas water heaters, furnaces, or both.

[3] No interest is included in the cost, as if the plant were built "overnight."

1.7 Energy Security

Use of natural gas provides another tool to enhance U.S. energy security by offsetting the dependence on petroleum products in key markets. Instability in the Middle East, coupled with growing demand from developing countries like Brazil, China and India, has tightened the supply-demand balance of global crude oil markets, in turn increasing prices and volatility and driving up consumer costs. More than 50 percent of total U.S. crude oil imports originate from countries belonging to the Organization of Petroleum Exporting Countries (OPEC), which, to varying degrees, face political instability, thereby putting the United States at risk of uncertain petroleum supply and price shock.

The majority of petroleum in the United States is used for transportation fuels, but a substantial portion of petroleum products are distillate fuel oils and kerosene used in homes and businesses for space and water heating. In 2009, about 6.9 billion gallons of distillate fuel oil were sold to residential and commercial customers, the equivalent of 620 million barrels of crude oil or about 13 percent of total oil and petroleum products imported to the United States each year. [xiii] But residential and commercial fuel oil usage has been declining in recent years and is expected to continue. The EIA Annual Energy Outlook 2011 projects heating oil consumption declining in the Northeast at 1.6 percent per year over the next 25 years, a result of higher petroleum prices and more stringent emissions standards.

A measured approach of increasing efficiency and incentivizing switching distillate fuel oil to non-petroleum based energy sources like natural gas and electricity, when these alternative options are available, can help reduce oil imports and ease the strain of tightening crude oil markets. It will also help reduce greenhouse gas emissions.

However, limited natural gas pipeline infrastructure in parts of the Northeast severely hinders natural gas utilization, so petroleum products and electric resistance heating are generally used instead. The cost of extending main and service lines to these areas is often prohibitive, as customer density rates are too low to be economically justifiable.

Still, limited conversions and new gas installations are taking place. AGA conducts an annual Residential Natural Gas Market Survey and in 2008 companies responding to the survey said that 14 percent of new customer additions were homes converted from another fuel to natural gas. Fuel oil represented 33 percent of these conversions, and 29 percent converted from electricity. The remaining 38 percent were unable to identify the previous heating fuel present in the converted household.[xiv]

From a policy perspective it is important to understand what impact an optimum conversion program could have on natural gas supplies. So, assuming a limiting case scenario where every home in the Northeast was converted to natural gas, what would be the estimated amount of natural gas required to serve them and what effect would that have on supply? Approximately 8.2 million housing units heat with fuel oil in the United States and 6.6 million reside in the Northeast. The consumption of heating oil per household during the 2010-2011 winter in the Northeast was projected to be 708.1 gallons, or 98.2 MMBtu, based on the EIA Short-Term Energy Outlook (Dec 2010). If each of the 6.6 million fuel oil households converted to natural gas, the volume of natural gas required would be about

825 Bcf, or about 3 percent of total U.S. natural gas consumption in 2010. This equates to 3.7 Bcf per day of new natural gas demand during the winter heating season. Given the recent increases in shale gas production, which has boosted overall natural gas dry production 6 percent in 2011 over 2010 levels, the fuel required to serve the heating needs of these households appears very manageable.

1.8 Distributed Generation and Clean Energy Technologies

Distributed generation (DG) technologies, in particular those supported by the natural gas distribution system, can play a key role in cost-effectively meeting future energy needs. DG technologies, which include combined-heat-and-power (CHP) applications, can reduce capital costs, enhance grid reliability, increase energy efficiency and drive greenhouse gas emissions reductions. Smaller scaled DG technologies, geared especially toward residential and commercial markets, can also offer modularity and flexibility, in contrast to today's central generation paradigm. And as the electric and natural gas markets continue to evolve, the potential for DG to integrate the natural gas system into the electric "smart grid" remains significant.

DG technologies are at various stages of maturity and market adoption. Some new gas-based technologies are still under development and not yet widely available, while others are more time-tested. Large-scale CHP applications, for example, have been used in the industrial and large commercial sectors for years. Its availability offers a near-term opportunity.

CHP, or cogeneration, is the simultaneous production of useful thermal and electrical energy from a single fuel source, thus CHP serves both on-site generation requirements and provides energy for heating, cooling and process applications. CHP operates at higher efficiencies than conventional electricity production, which reduces operating energy costs. And because electricity is generated onsite, a CHP unit can enhance power reliability, especially if the consumer is connected to the electric grid. Natural gas is the primary fuel for existing CHP. In 2011, 71 percent of CHP installations utilized natural gas.

The key constraint of many DG and CHP technologies is the upfront purchase and installation costs, which often prevent achieving viable project economics. Lower operating costs offer consumers a payback on this initial upfront investment, but CHP is typically limited to consumers with large thermal and electric loads so that the payback period is short enough to make the project economically viable.

Therefore, industrial and large commercial customers traditionally have been the primary market for CHP. Today, 82 gigawatts of installed CHP serve almost 4,000 industrial and commercial facilities. Manufacturing facilities, chemical production plants, petroleum refineries, and paper mills comprise much of the industrial CHP installed capacity, and about 12 percent of the total CHP capacity is used in the commercial / institutional sector such as universities, hospitals, and prisons.[xv]

In addition to cogeneration, there are a number of potential or existing distributed energy technologies that can operate on natural gas:

- **Fuel Cells** produce electricity and heat using an electro-chemical reaction. Fuels vary from pure hydrogen to fossil fuels, including natural gas. Fuel cell type, size, and efficiency vary tremendously. The cost of fuel cell capacity (kW) is currently about 7-10 times that of a combined-cycle combustion turbine.[xvi] Fuel cell units are available for large-scale commercial applications, and while smaller-scale commercial and residential units are currently being explored and tested, they are not yet widely adopted.
- **Gas Turbines** – These are mid- to large-scale turbines that operate in the 50 kW to tens of MW range. These turbines are typically used in cogeneration scenarios for industrial processes.
- **MicroCHP** represents cogeneration on smaller scales, typically the 1-5kW electric load range, which suits the thermal and generation load needs of residential and small commercial consumers. Net metering[4] would be typically required for full savings to be realized.
- **Microturbines** are similar to their larger gas turbine brethren, but operating in the 25-500 kW range instead of MW. They are fueled by natural gas, diesel, propane, or hydrogen. Microturbines can achieve higher efficiencies if the waste heat from generation is re-appropriated for secondary use. Because of their large size, they are mostly suited for larger scale commercial and small industrial applications.[xvii]
- **Reciprocating Engines** – These engines range in size from a few kW to over 5 MW and are mostly found in large commercial and industrial sites, but can be used in the residential sector for in multi-family units and for small scale residential backup generation.[xviii]

The benefits of distributed generation technologies are significant, but depend on the technology and how it is used. In a report on fuel cells the Rocky Mountain Institute captured many of the benefits, listed below. These represent a generalization of the value consumers, utilities, and society may derive from DG technologies. [xix]

- **Electrical energy value** – the economic value of the electrical energy produced by the system.
- **Thermal energy value** – the value of waste heat recovered from the unit.
- **Option Value** – added value of a generation option that can avoid over-building of central-generation capacity for an area.
- **Deferral Value** – the economic value of deferring new transmission and distribution capacity in a high-cost area.
- **Engineering cost savings** – reducing the economic costs to electric distribution utilities by reducing costs in the operation and maintenance of T&D systems.
- **Customer reliability value** – the value of increased reliability power.
- **Environmental value** – lower emissions provide added value under regulatory regimes that restrict certain pollutants and drive generation costs higher.

As consumer technology choices advance, direct-use natural gas serving these distributed generation technologies can add value for the consumer and the utility. Thoughtful public policy should ensure that

[4] Net metering policy allows for consumer credit for excess distributed-generated electricity fed back into the grid.

consumers are presented with cost-effective energy options while supporting infrastructure build-out and improvement to enable these options.

2 Disturbing Trends and Constraints

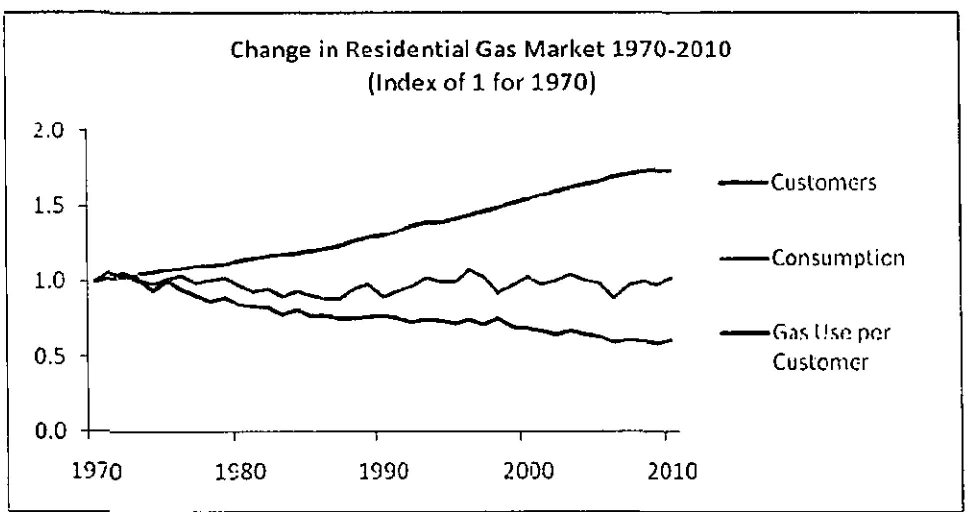
Summary

Natural gas efficiency has improved over the last 40 years, which partly explains why natural gas consumption remains flat despite a growing customer base. In addition, in recent years the installation of natural gas in new homes has slowed, the result of a combination of market factors, especially first-cost issues, regulatory constructs, and economically perverse incentives from competing energy sources.

2.1 Introduction

Over the last three decades, the residential and commercial natural gas markets have been shaped by *two opposing trends: customer growth and the decline in gas use per customer. These trends have* counterbalanced, leading to virtually no increase in the amount of gas consumed in the residential sector. Since 1970, natural gas use per customer has declined 39 percent on a weather-normalized basis. In contrast, electricity use per customer has increased 63 percent during the same period.

Figure 9



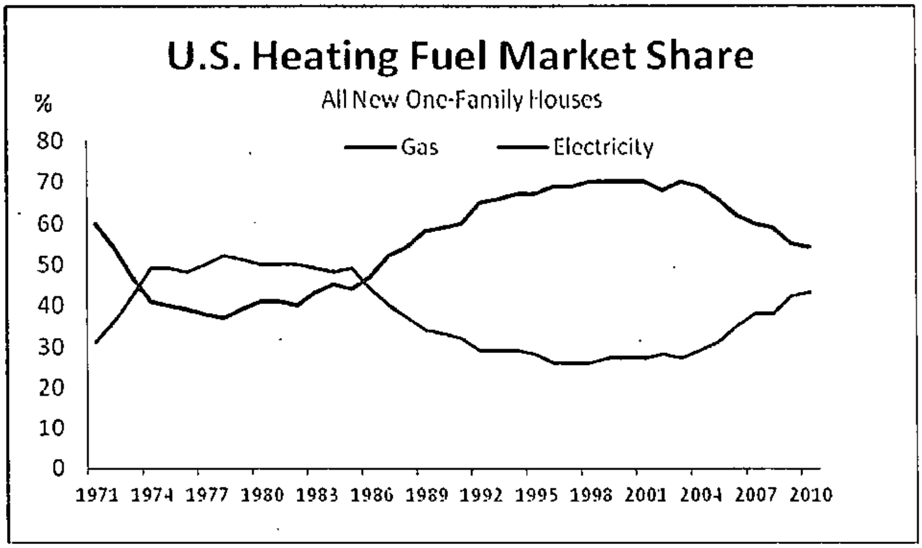
Several factors have driven the declining use per customer trends:

- Increased efficiency in space heating equipment and building shells.
- Historical increases in *natural* gas costs and price volatility.

- Population migration to warmer climates

For most of the past several decades, natural gas has been the preferred fuel for primary space heating in new homes. However, in recent years the natural gas share of the new home market has slipped. Figure 10 shows trends in the home heating fuel market for newly constructed single-family homes. For the United States as a whole, gas share (data includes natural gas and propane) of the new home heating market has been shrinking over the last decade. In 2010 gas share of single-family new home construction was 54 percent, down from the peak of 70 percent in 2003. Meanwhile, electricity has filled the gap left by gas. Electricity share has grown over this same period and in 2009 was 43 percent, up from its low point in 1998.

Figure 10



Source: US Census Bureau

Higher natural gas prices and increased volatility from 2000 to 2008 contributed to the decline in natural gas market share. Additionally, competing electric applications have contributed to the erosion of natural gas market share. New air-source and ground-source electric heat pumps can maintain their efficiencies and operate in colder climates, leading to competition in traditionally gas-only areas.

Regionally, the trends show some differences. In the Northeast, the gas share of the new home heating market has undergone significant growth over the last 10 years. Households once served by fuel oil have switched to propane and natural gas. Conversely, the South shows the opposite. The share of gas installations, which a decade ago was evenly paired with electricity, now represents only one-third of the market. In the West and Midwest, gas installations have declined as well; trends there are similar to the national view depicted in Figure 10.

In addition to changes in technology and prices, other key constraints have hindered customer adoption of natural gas. The remainder of this section is will describe these constraints and trends, including:

- **First cost** purchase and installation of gas equipment and appliances.

- **Misaligned incentives** of building contractors and end-use consumers.
- **Economically perverse incentives** from electric utilities in the form of monetary incentives to consumers and builders.
- **Inconsistent site-versus-source standards** in regulatory and programmatic approaches to measuring energy consumption in efficiency, appliance standards, and green building programs.

2.2 First Cost Impact

The first-cost impact of installing natural gas equipment on consumers and builders is a primary impediment to natural gas use in residential and commercial buildings if service can be made available. In general, the cost to purchase and install a natural gas appliance is higher than an electric appliance. This creates an upfront cost impact on consumers and builders who might want a natural gas appliance because of its operating cost and comfort advantages. However, because of resource constraints or merely preference, consumers may opt instead for the lower-cost alternative and not choose natural gas.

There are a number of key consumer decision points when evaluating first cost. Appliance size and efficiency, the ease of installation, and the availability of gas service (the proximity to a gas main or service line) all factor into the upfront cost calculation. Higher efficiency appliances generally incur higher costs, and the cost of a building retrofit is generally higher than new construction. Appliances with condensing units, which re-appropriates the appliance's waste heat to increase its efficiency, are more expensive. These units often cannot be accommodated in older homes without additional ventilation equipment and construction due to building code requirements, so the cost of retrofit is often higher than the cost of new construction, where architectural plans can be altered to accommodate the installation. If new natural gas service is required for the appliance, installation costs can increase even further.

This difference in upfront cost between new construction and retrofit installation costs has significant implications on appliance code standards. Appliance standards mandate minimum efficiency requirements on manufacturers. Before an appliance standard is enacted, the proposed standard, or rule, must be accompanied by a technological feasibility assessment and an economic justification. For the rule to be economically justified, the mandated improvement in efficiency must create savings through lower operating costs for enough consumers over the lifetime of the equipment in order to pay back the higher upfront expense. This cost calculation changes depending on whether the equipment is installed as part of a new construction or a retrofit. Since retrofits, on average, are more expensive than those in new construction, consumers who wish to convert to natural gas, or replace an older unit with a higher-efficiency model, must incur these higher costs or switch instead to an alternative energy source. As a result, natural gas may be pushed out of markets where it could offer the greatest advantage in emissions reductions, which is the point of the appliance standard in the first place.

2.2.1 Water heaters

Natural gas water heaters are typically more expensive than electric water heaters with similar load and efficiency requirements. AGA conducted an analysis of minimum- and high-efficiency gas and electric storage water heaters that compared the installation and operating costs of four types of water heaters over their useful lifetime. The analysis uses data on efficiency, installed costs, and average lifetimes of residential water heaters from the U.S. Department of Energy Technical Support Document (TSD) on water heaters, and annual usage data from an EPA Energy Star residential water heater Final Criteria Analysis.[xx] It shows that a consumer's operating expenses over the lifetime of a minimum-efficiency natural gas water heater are half that of a minimum-efficiency electric storage heater.[xxi]

In the analysis, the average installed cost for a minimum-efficiency gas water heater is $1,079, about two times the $569 cost of minimum-efficiency electric water heater. Higher-efficiency units have a corresponding price premium and the price relationship between equipment of both fuel types remains consistent. The average installation cost for a high-efficiency gas storage water heater rated 0.65 EF is $1,591, more than twice the average cost of $711 for an electric resistance water heater. Table 7 details the prices for these water heaters.

Table 7: Water Heater Installation and Total Costs ($2009)[xxii]

Storage Water Heater Type		Site Efficiency (EF)	Installed Cost	Yearly Energy Cost	Life (Years)	Total Cost
Gas	Minimum efficiency	0.59	$1,079	$284	12	$4,487
	High-efficiency	0.65	$1,591	$251	12	$4,603
Electric	Minimum efficiency	0.90	$569	$563	14	$8,451
	High-efficiency	0.95	$711	$533	14	$8,173

Blue box indicates a price advantage; the red box indicates a price disadvantage. The high-efficiency electric storage water heater has a lower installed cost than a gas unit, but has twice the total lifetime cost when operating expenses are included. Based on data from the DOE Technical Support Document for Water Heaters (2009).

But a natural gas water heater costs less to operate than an electric water heater. Using average annual usage data from the TSD and annual fuel prices reported by DOE in the federal register, the average annual energy cost for a minimum-efficiency natural gas water heater is $284, compared with $563 for a minimum-efficiency electric water heater (assuming $11.21 per Mcf for natural gas and 11.54 cents per kilowatt-hour for electricity).

The lifetime operating costs for a natural gas storage water heater is so much lower than electricity, in fact, when the operating costs are added to the upfront cost, natural gas represents the lowest *total*-cost option. The total cost of a minimum-efficiency natural gas water heater is $4,423, or 47 percent lower than the $8,303 for a minimum-efficiency electric water heater. A similar analysis for high-efficiency units (the natural gas water heater is rated 0.65 EF [energy factor]; the electric 0.95 EF) shows the gas unit costs 43 percent less than the electric version. The average installation, operation, and total costs of gas and electric appliances for both minimum standard site-efficiency and high-efficiency options are laid out in Table 7.

2.2.2 Space Heating Systems

Comparing replacement natural gas and electric space heating systems also shows that natural gas space heating appliances typically have higher upfront costs but lower operating costs. A recent AGA analysis of replacement HVAC equipment concluded that, compared with an electric heat pump, a natural gas furnace, on average, costs more for its purchase and installation, but costs less to operate, resulting in lower overall costs for the lifetime of the equipment.[xxiii]

The analysis presents a cost assessment of two equipment replacement scenarios. The first scenario evaluates the cost of a natural gas furnace for space heating and an electric air conditioner for cooling. The second scenario evaluates the costs of a stand-alone electric heat pump, which can serve space cooling and heating requirements. (Because of the heat pump's dual capability, the installation and operating costs of the natural gas furnace in the first scenario must include an air conditioner to make the cost comparison analysis equitable with the electric heat pump.) All of the equipment performance ratings are set at the federal minimum-efficiency standard and operate on an 18-year lifecycle. The results are shown in Table 8.

Table 8
Replacement Natural Gas Furnace and Electric Heat Pump Life Cycle Comparison

	Scenario 1: Natural Gas Heat, Electric Cooling			Scenario 2: Electric Heat & Cooling
	Natural Gas Furnace	Electric Central Air Conditioning	Total for Both Systems	Electric Heat Pump
Appliance Cost	$809	$1,761	$2,570	$2,483
Installation Cost	$782	$489	$1,271	$455
Average Annual Fuel Cost	$797	$252	$1,049	$1,262
Annual Maintenance & Repair	$42	$131	$173	$122
Life Cycle Cost - NPV			$19,053	$19,467

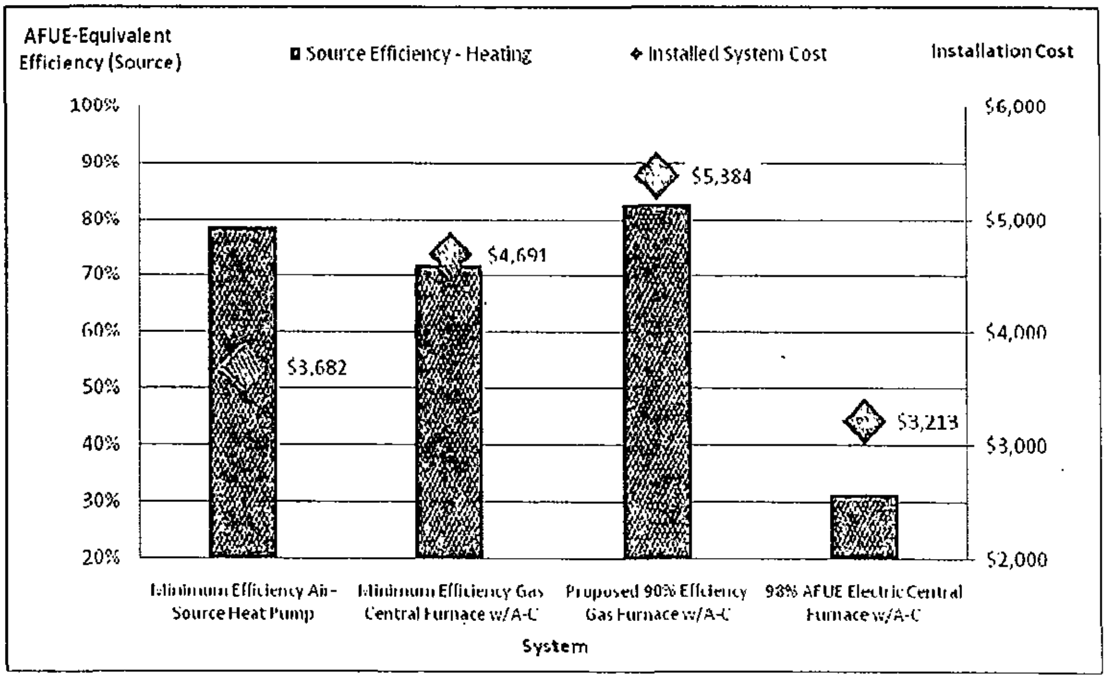
Source: AGA Financial and Operational Information Series, based on analysis of DOE Technical Support Document.[xxiv]

The natural gas furnace plus the air conditioner has an average combined appliance and installation cost of $3,841, while the less expensive electric heat pump costs $2,938, or 23 percent less than the furnace-air conditioner combination.

However, over the lifetime of the equipment, the reduced operating expenses of the gas furnace-air conditioning system makes up for the higher upfront costs. On average, a consumer will pay $1,049 annually for natural gas and electricity expenditures. By contrast, the average cost to operate a heat pump is 20 percent higher, totaling $1,262 annually. When all expenditures are factored in over the lifetime of the equipment, including repair and maintenance costs, the cost advantage for the natural gas system is $680, or about three percent. Any decrease in natural gas price, or increase in the price of electricity, makes this comparison more favorable for gas.

But how well do these different systems perform in terms of source efficiency? AGA evaluated a range of space heating appliance options to compare the relative source efficiencies and the costs of purchasing and installing these systems. The analysis included a minimum-efficiency air-source heat pump, a minimum and a high-efficiency natural gas furnace, and an electric resistance central furnace. Installation costs for the systems were taken from the DOE Technical Support Documents for natural gas furnaces, air conditioning units and electric heat pumps, as well as installation costs from the NREL Retrofit Measure Database for electric central furnaces. The analysis included new construction and replacements; therefore, the installation costs reported here are slightly different than the costs shown in Table 8, which were for replacements only.

Figure 11
Efficiencies and Installed Costs for Central HVAC Systems



Source: DOE Technical Support Document.

Note that *installed system cost* encompasses equipment purchase and installation and represents a weighted-average representative sample of households including new construction and replacement. As a result, the cost data differs somewhat from Table 8, which shows costs for replacements.

Figure 11 illustrates the differences in the installed cost and equivalent source energy efficiency of the different HVAC systems. The electric furnace (rated efficiency of 98%-AFUE) enjoys the lowest installation costs; however it has the lowest source heating efficiencies as well (32%). A minimum efficiency air-source heat pump has an installation cost of $3,682 as well as higher source heating efficiencies compared with a minimum-rated natural gas furnace. A minimum-efficiency gas furnace on average costs $4,691. The 90% efficient gas furnace had the highest source efficiency, but also the highest installed system cost of $5,384.

2.3 Builder Decision and Resistance to Gas Use

The builder decision to install a natural gas appliance, or suite of applications, is primarily driven by three principal factors:

- Natural gas availability
- Economic impact on the builder
- Consumer preference

Typically a gas utility will extend service to a new customer if the associated costs fall within the parameters (lengths of line, revenue test, return on investment, etc.) set by the utility and regulators. If the cost of extending service exceeds those parameters, the gas utility may require that the customer make a contribution in aid of construction (CIAC) to cover the revenue shortfall. Since a builder is unlikely to make this contribution, the responsibility rests with the customer. This added cost often deters the customer from switching to natural gas.

If natural gas service can be made available, the economics of installing a gas application will drive the builder decision process. The following factors often limit and inhibit the natural gas installation into a household:

- **Higher first cost for gas appliances** may incent a builder to choose a non-gas application unless the consumer demands a gas appliance or the added value of gas in a household to the builder is not demonstrably greater than the cost of installing gas.

- **Larger architectural footprint** within a structure is typically required for natural gas. Natural gas appliances and equipment tend to be physically larger than electric equipment. With floorspace at a premium in buildings, bigger rooms and more floor area to accommodate gas equipment negatively impact available square footage in the household. Generally the lower the square footage available in a household, the lower the asking price.

- **Equipment requirements**, such as ventilation equipment and in-house piping, adds additional cost for a natural gas installation.

Builders are increasingly reluctant to use gas equipment because of the higher costs unless the consumer demands the appliances. Unfortunately, most of the homes today are starter homes, and these buyers prefer the lower cost of the electric home.[xxv] A builder will receive no payback on the investment of a natural gas appliance. Therefore, the motivations of a builder to choose natural gas are not aligned with the consumer.

2.4 Economically Perverse Incentives

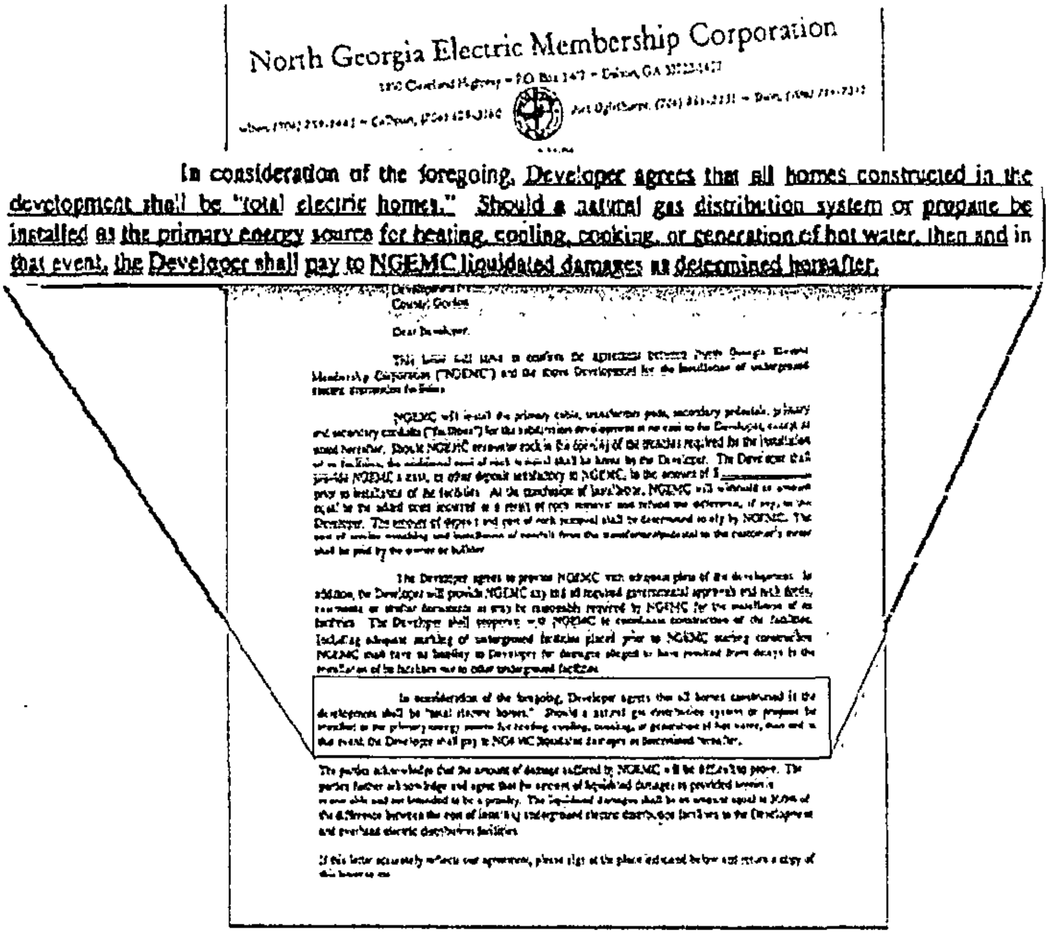
Natural gas markets face competitive pressures from other energy providers. For example, electric utilities sometimes provide economically perverse incentives to discourage natural gas use. These incentives can take the form of lower service rates for all-electric consumers, rebates to consumers to replace natural gas equipment with an electric appliance, and service fee waivers to builders that choose an all-electric installation.

There are instances where all-electric customers enjoy lower electricity rates than a customer with natural gas and electricity. The following are some examples of rate structures and schemes:

- **Discounts for all-electric customers**
  There are instances where segments of an electric utility's customer base will subsidize others in order to promote all electric homes. For example, in the wake of the 1970 moratorium on new natural gas installations, the Public Utility Commission of Ohio (PUCO) allowed an electric utility to offer discounted electric rates to customers that lived in all-electric homes. Customers with natural gas would pay higher electric rates, which in effect subsidized the discounted customers. These rates remained in place even after the gas moratorium ended. In the wake of concerns that some electricity customers were subsidizing the discounts of others and in an effort to promote greater energy efficiency, in 2007 the all-electric discount was eliminated for new customers. By 2009 the all-electric customers moved to the standard residential distribution and generation rate but still received a small discount (approximately 1.7 cents/kWh distribution discount, and 1.9 cents/kWh generation). Under pressure from customers who saw their rates rise dramatically during the winter, the utility instituted a residential generation credit (RGC) for its customers in place of the now eliminated all-electric rate cut. This new discount depended on service area and customer usage but went as high as 4.2 cents per kWh (this is in addition to the generation and distribution discounts already mentioned). The fate of the credit and discount rate is currently being decided.

- **Seasonal rates**
  For qualified customers with electric space heating or all-electric households, electric utilities may offer a seasonal rate for service that is less in the winter months relative to the summer. Consumers with an alternative energy source for space heating, such as natural gas, would not have access to these lower rates. Consequently, the higher electric rates paid by customers with natural gas heating effectively subsidize the all-electric customers that enjoy lower seasonal rates. Utilities that use seasonal charges and a declining block rate—the more energy a customer uses the less they pay—further incentivize greater electricity usage, adding additional competitive pressure.

Figure 12: Letter from Electric Membership Corporation to Developer Incentivizing All Electric Households.


North Georgia Electric Membership Corporation

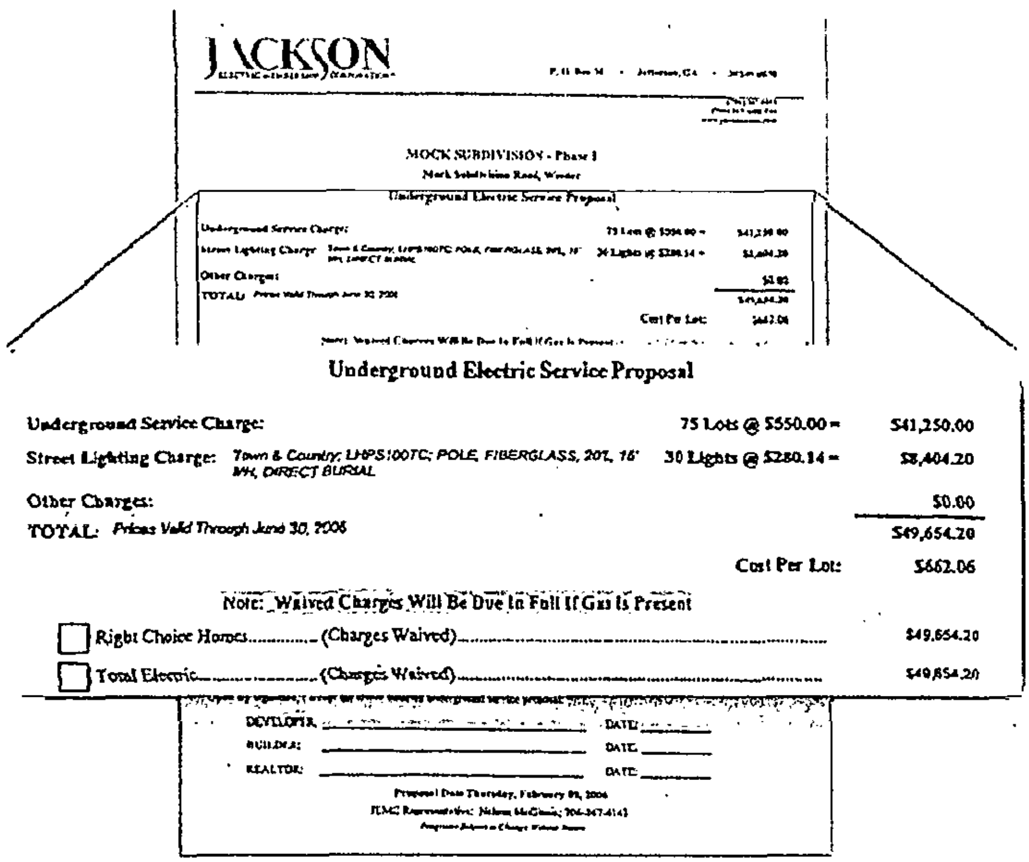
In consideration of the foregoing, Developer agrees that all homes constructed in the development shall be "total electric homes." Should a natural gas distribution system or propane be installed as the primary energy source for heating, cooling, cooking, or generation of hot water, then and in that event, the Developer shall pay to NGEMC liquidated damages as determined hereafter.

The developer must agree to build a household with only electric appliances in order to receive the discount

There are also financial or non-rate side incentives. These are not part of a consumer's energy rate structure, but financed using shareholder dollars. Electric companies sometimes offer discounts, rebates, tax incentives, payments to builders, and other financial incentives. The dollars to finance the incentives come from the utility's shareholder dollars—the company's profit base—and are not embedded into the regulated rate base charged to consumers. The upfront costs to the shareholders are viewed as an investment to ensure the long-term capture of an all-electric customer who will provide a long-term return on the shareholder investment.

In some cases, builders are offered direct incentives to construct homes with only electric appliances. For example, an electric service provider will offer to install electric wiring underground in a housing development, which is viewed as a premium compared to overhead wires, albeit a costly one. However, if the builder agrees to all-electric homes the service fee charges are waived, saving the builder considerable costs. If natural gas appliances are installed the builder must pay the service fee, per agreement with the electric utility. The builder now has considerable incentive to forgo natural gas appliances. Figure 12 and Figure 13 show two electric service proposals to builders as examples of these incentives.

Figure 13: EMC Electric Service Proposal


JACKSON

MOCK SUBDIVISION - Phase I

Underground Electric Service Proposal

Underground Service Charge:		75 Lots @ $550.00 =	$41,250.00
Street Lighting Charge:	*Town & Country; LHPS100TC; POLE, FIBERGLASS, 20T, 16' MH, DIRECT BURIAL*	30 Lights @ $280.14 =	$8,404.20
Other Charges:			$0.00
TOTAL:	*Prices Valid Through June 30, 2006*		$49,654.20
		Cost Per Lot:	$662.06

Note: Waived Charges Will Be Due In Full If Gas Is Present

☐ Right Choice Homes............(Charges Waived)........................ $49,654.20

☐ Total Electric....................(Charges Waived)........................ $49,654.20

DEVELOPER: ______ DATE: ______

BUILDER: ______ DATE: ______

REALTOR: ______ DATE: ______

All Fees are waived if gas is *not* installed.

2.5 Inconsistent Approach to Energy Codes and Standards

There are many structural disincentives for natural gas in the form of building and energy codes, appliance standards, energy rating systems, and other state- and federal-level policies. Voluntary programs, compulsory codes and standards, and energy rating methodologies can be developed using either a site-based or full-fuel-cycle (FFC)-based approach to energy measurement. Site-based approaches have an inherent bias against natural gas since natural gas appliance site efficiencies are often lower than electric, despite natural gas having higher source-to-site efficiencies. Approaches that do not incorporate a comprehensive approach to energy measurement create an unequal playing field for natural gas relative to other competitive fuels and may bias towards energy sources that may overall be more energy or greenhouse gas intensive.

A FFC approach to codes and standards development would account for source efficiencies and environmental emissions from the value chain of any energy source, thus providing a more comprehensive mode of energy measurement and a more holistic perspective on fuel choice. If the goal of a policy or program is to reduce energy, minimize pollution, mitigate greenhouse gases, or other environmental- or health-related impacts, the most appropriate methodology for evaluating technology and fuel options must incorporate a comprehensive approach such as full fuel cycle. It should be employed in a manner that results in codes and standards that are technologically feasible, economically justified, and effective in reducing overall greenhouse gas emissions.

There is no single methodological approach in the development of policies, model building energy codes, energy rating systems, appliance performance standards, and other regulatory regimes. Whether a site approach or FFC approach is used depends on the program itself, and no policies currently provide guidance on this issue. The result is a varied suite of obligatory and voluntary programs of inconsistent design, leaving unrealized the full understanding of energy choice impacts, and in turn limiting the effectiveness of these many energy programs, policies and regulations.

Table 9 provides a list of voluntary and compulsory programs, categorized by those using a site or FFC approach. The remainder of this section discusses some of these programs.

Table 9: List of Programs by Energy Measurement Approach

Programs with Site-Energy Approach
o DOE Appliance Codes & Standards o EPA Energy Star, National Energy Rating Program for Homes o National Association of Home Builders, National Green Building Program o Residential Green Building, Green Building Initiative o U.S. Green Building Council, LEED Rating System

Programs with Source / Full-Fuel-Cycle Energy Approach
o DOE, Residential Retrofit Guidelines o DOE, Federal Petroleum-Equivalent Fuel Economy Calculator o EPA Energy Star, Commercial Buildings Program o Green Building Initiative, Green Building Assessment Protocol for Commercial Buildings o International Green Construction Code (IGCC) V2 Performance Path, ICC o U.S. Green Building Council, LEED for Existing Building O&M Rating System

Programs related to the establishment of appliance minimum performance ratings are particularly influential. Minimum standards affect the floor price of an appliance's upfront cost, which impacts consumer options and choice. However, the current standards do not properly reflect the most *cost-effective* minimum standards that result in the greatest environmental benefit. The problem is how the standards are determined. The Department of Energy is compelled under statute to determine appliance standards based on site energy. The Energy Policy and Conservation Act of 2005 requires the secretary of Energy to prescribe or amend new energy conservation standards for each type or class of identified product, and although DOE may utilize primary or source energy consumption in some analyses to determine whether a particular standard is economically justified, the final rule promulgated must determine a site-efficiency standard.[5] A site-based approach is appropriate when comparing single-fuel product types. A FFC approach is necessary to understand the energy and environmental impacts – and the market implications of a minimum standard set on these appliances – between different fueled products. In a recent study the National Academies weighed in on this subject: "Site-energy use is also the most appropriate measure for setting operational efficiency requirements for single-fueled appliances within the same class." However, the study also notes and endorses "full-fuel-cycle measure of energy efficiency as integral to supporting more explicit consideration of the impacts of energy use on the nation and the environment." A more comprehensive approach, as the National Academies supports, would better level the playing field to provide the most cost-effective consumer choices that reduce energy and environmental impacts.[xxvi]

In other programs, the energy-measurement approach is selected by the agency itself. The Environmental Protection Agency (EPA), for example, establishes its voluntary ENERGY STAR building qualifications using analytical modeling tools, or energy rating systems, to assess building efficiencies and provide a rating. EPA utilizes two energy rating systems, one for residential households and another for commercial buildings. Both rating systems rely on measuring and modeling the energy consumption of a building based on the structure's attributes, such as types of appliance and equipment installed. Buildings that perform better – use less energy – than specified thresholds qualify for ENERGY STAR, which brands the building design as energy efficient.

One reason the rating system is different for commercial buildings is the nature of the structures being rated. Residential buildings are more homogenous and are more easily comparable. Commercial buildings vary in size, shape and usage, ranging from small storefronts, to mid-sized grocery stores, to large campus institutions for corporations, hospitals and universities. Therefore comparisons between commercial buildings require the various building types to be lumped into peer groups that share similar attributes and operational characteristics.

However, many of the key differences between the two approaches are a matter of precedent. When EPA began developing the residential ENERGY STAR program, the Residential Energy Services Network (RESNET), a group of certified home energy professionals, was finalizing a comprehensive residential Home Energy Rating System (HERS), which EPA finally chose as the methodological backbone for its residential ENERGY STAR program. When EPA began the Commercial Buildings Program, it did not have a similar efficiency rating system for commercial structures, so it developed a separate national energy performance rating. One key difference between the systems was the energy measurement calculation: the residential program used a site-based approach, while the commercial side relied on source-based calculations.

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[5] DOE is proposing to move from a source to a more comprehensive full-fuel cycle approach as part of these analyses.

The HERS Index scale compares a household's purchased energy consumption with the same type of household built to International Energy Conservation (IECC) 2009 code. As noted, the HERS Index was based on the site-energy consumption of the household, but over time this initial approach was found to have flaws and has since been modified.. Today, the HERS efficiency rating uses a calculation that is fundamentally site-based with an adjustment factor to make more equitable the technological differences in improving efficiencies between appliances of different fuel types. The calculation also uses a correction factor to account for the efficiency of direct-energy consumption. However, there are significant problems with the HERS methodology: 1) it does not account for the ranges and differences in efficiency of using coal and natural gas for electric generation; rather an average efficiency is utilized; and 2) it does not factor in the carbon intensity of the electric generation mix. This approach does not acknowledge the full-fuel-cycle efficiencies of natural gas and competitive fuels, again limiting the ultimate effectiveness of the program.

The EPA commercial buildings national energy performance rating instead uses a source-based methodology.[6] The national energy performance rating scale is similar to the HERS index for residential structures in that it provides an external benchmark with which to compare a similar peer group of buildings and rate their energy performance. The scale is determined for each peer group by assessing a building's total energy usage relative to its operation, and how much energy do they use relative to each other on a source energy basis. The source energy basis, not incorporated into the EPA residential HERS rating, is a keystone of the EPA commercial buildings energy analysis. EPA acknowledges the superiority of this methodology, which, according to the EPA office assigned to assess energy usage in building and plants, "is the most equitable way to compare building energy performance, and also correlates best with environmental impact and energy cost."[xxvii]

There are other cases of site-based methodological approaches to assessing, modeling, and codifying home and building energy consumption and standards, as well as inconsistencies within the programs themselves. The National Association of Home Builders residential sector "Green Building Program" is designed with a site-based efficiency measurement at the heart of its energy consumption calculation. This program is also incorporated into residential activities of the *Green Building Initiative*, a non-profit organization created to promote and accelerate green building practices. However, the *Green Building Initiative* also developed the "Green Globes" tool as a guidance and assessment tool for construction and retrofits of commercial buildings. This assessment protocol and rating system utilizes a life-cycle approach, which encompasses the full-fuel-cycle, for its materials and energy consumed in the building.

In the same vein, the U.S. Green Building Council's LEED rating system for new and retrofit buildings assigns points based on the efficiency of the heating system installed, but neither penalizes nor rewards designs that consider source energy consumption and emissions. The LEED O&M rating system for existing buildings, on the other hand, uses a source-based approach.

Clearly there is no one universal methodological approach to energy measurement that will apply in all cases, nor should there be. Energy consumption exists at the heart of these programs and policies,

[6] In this case it acknowledges energy losses related to electricity generation, transmission, and distribution, but sets aside losses related to primary fuel extraction, processing, and transportation.

which are designed to increase efficiency and reduce greenhouse gas emissions. Maximizing site efficiency should not be achieved at the expense of source energy losses. Programs and policies should be designed with the most comprehensive approach feasible. A full-fuel-cycle mode is more complex and requires more data, but it is feasible. As the National Academies acknowledged in its report on appliance efficiency standards, "a [full-fuel-cycle] methodology can be developed without undue strain on DOE/EERE resources." But ultimately policies should be designed to support and achieve important public policy goals while simultaneously benefiting consumers. A thoughtful, full-fuel-cycle approach can help enable that possibility.

3 Policy Recommendations

Summary

The following policy recommendations are made to ensure that direct use of natural gas can make a long-term contribution to increasing energy efficiency and reducing overall emissions in homes and businesses. These policies should be considered in the context of overall U.S. energy policy:

- Develop and incorporate full-fuel-cycle analysis into energy policy, regulations and energy efficiency metrics.
- Provide consumers with the best available information on comparable energy options through the use of enhanced appliance and equipment labeling, including carbon footprint information.
- Encourage government agencies, state public utility commissions, and utilities to jointly develop innovative policies and regulations that provide better alignment of costs and benefits over the life cycle of consumer equipment.
- Research and development programs and investment focus should include natural gas delivery and end-use technology to fully maximize the value of natural gas resources.

The preceding chapters explored the benefits and the constraints on the direct use of natural gas to contribute to consumer and societal goals. Based on these issues, the following recommendations are suggested for consideration as part of larger domestic energy policy in order to maximize the benefits of direct use so that natural gas can contribute to greater energy efficiency and lower emissions in homes and businesses. Prudent policies and regulations are essential if consumers and society are to fully realize these benefits. As energy delivery systems evolve and the electric grid becomes more integrated with the natural gas distribution system, thoughtful policy can help to integrate new and existing natural gas technologies with current infrastructure to provide enhanced system reliability, lower costs, lower environmental impacts, and greater accessibility and choice for consumers.

Recommendations

1) Develop and incorporate full-fuel-cycle analysis into energy policy, regulations, and energy efficiency metrics.

It is imperative to consider all points of energy consumption and sources of emissions when creating policies for the cost-effective reduction of energy use, criteria pollutants, and greenhouse gases. All sources of energy and emissions along an energy value chain, from the point-of-use to the energy delivery system itself, should be fully and comprehensively accounted.

For example, energy sources such as electricity may have zero site-based greenhouse gas emissions, but, depending on the primary fuel source, may still result in significant emissions from the generation of electricity. Ignoring this can lead to unintended consequences, and policies designed to reduce energy or emissions can, in fact, preclude decreases or even lead to increases in energy and emissions. This is especially true for policies regarding consumer appliances and fuels in which interchangeable options have unequal environmental consequences.

Therefore a full-fuel-cycle analysis is appropriate. Full-fuel-cycle evaluates the energy consumption and environmental impacts (such as emissions) from energy extraction, processing, transportation, distribution and (in the case of electricity) generation, in addition to an evaluation of the final consumption of a fuel source. Energy consumption and emissions, therefore, should not be merely evaluated at point-of-use, but throughout the entire energy value chains.

Full-fuel-cycle analyses could be best integrated into energy policies, regulations, green building programs, consumer awareness and education programs, and energy codes and standards, in order to provide a better basis for comparing appliances and equipment of different fuel types. Examples of where full-fuel-cycle could be integrated include:

- Appliance minimum performance standards
- Model building energy codes and standards
- ENERGY Star qualification
- Building energy rating systems
- Consumer information, e.g. appliance labels with carbon footprint information.
- Consumer education, e.g. 'Where does your electricity come from?'

To develop an agreed-upon full-fuel-cycle methodology will require some effort. There is currently some uncertainty regarding upstream energy consumption and greenhouse gas emissions factors, in particular those of coal and natural gas extraction. In addition, there are significant regional differences regarding full-fuel-cycle analyses because of geographical variations, electric generation mix and climatic differences in appliance usage trends. However, these challenges are not overwhelming and they do not detract from the reality that a full-fuel-cycle analysis provides a more comprehensive approach to evaluating the environmental impacts of energy usage.

Prudent policy should set a course for state and federal government agencies to establish an agreed-upon full-fuel-cycle methodology that embraces the inherent regional characteristics of the full-fuel-cycle and then adopt it into the appropriate energy and environmental metrics.

2) **Provide consumers with best available information on comparable energy options through the use of enhanced appliance and equipment labeling.**

Enhanced information on appliance energy consumption and costs enables informed consumer decisions on energy choices. The EnergyGuide label, issued by the U.S. Federal Trade Commission, is commonplace on many retail consumer appliances, including furnaces, hot water heaters and heat pumps, and informs consumers of that particular appliance's energy efficiency, estimated yearly operating cost, and annual energy use.

The EnergyGuide label could be further enhanced with more information detailing the appliance's environmental impacts, in particular greenhouse gas emissions. A full accounting of these emissions would require a full-fuel-cycle analysis. While this approach is somewhat more complicated and adds to the complexity of the EnergyGuide label, it provides consumers with a carbon footprint, an important detail for many consumers making purchasing decisions. Despite the challenges and complexities, an enhanced EnergyGuide label would be a low-cost method of incentivizing better carbon choices by consumers through consistent, comparable, and verifiable information on energy use and greenhouse gas impact.

3) **Encourage government agencies, state public utility commissions, and utilities to jointly innovate policies and regulations that provide better alignment of benefits and costs over the life cycle of consumer equipment.**

There is significant potential for natural gas to cost-effectively contribute to public goals such as reduced oil dependence, greater energy efficiency, and reduced greenhouse gas emissions. Key economic constraints stand in the way, however. The higher cost of gas appliances and the added costs to extend main and service line extensions often deters customers from switching to natural gas. Measured and prudent policy and regulation can help ease these market constraints and provide a greater alignment of long-term benefits and costs.

Government agencies, state public utility commissions, and utilities should be encouraged to develop innovative policies and regulations to reduce these barriers. These policies could include the development of novel rate designs, new financing mechanisms, rebate programs, and changes to the tax code to support infrastructure build-out. Policies could include:[7]

- The leasing of utility-owned equipment to customers or providing similar financial mechanisms that allow the utility to bear the first-cost burden to relieve the customer of the upfront cost associated with natural gas.

- Deferring customer contributions in aid-of-construction for natural gas main and service line extensions by creating a regulatory liability and amortizing payments over time.

- Supporting utility infrastructure build-out as part of economic development programs through tax abatement, special pricing areas, direct contributions and others, as a way to support business development, job creation, plant expansions, and customer fuel savings.

- Providing rebate programs for customers who upgrade to high-efficiency natural gas equipment.

- Eliminating taxes on the customer contribution in aid-of-construction for natural gas main and service line extensions.

4) **Research and development programs and investment focus should include natural gas delivery and end-use technology to fully maximize the value of natural gas resources.**

Robust research and development plays a crucial role in technological development. In recent years, significant focus has been on upstream technological advances, especially new production techniques. But as infrastructure ages and existing home and business owners replace older appliances and equipment, there remains a need to focus on R&D for natural gas distribution and end-use technologies. R&D initiatives should include priorities to improve existing technologies and develop new solutions with the goal of maximizing the use of natural gas resources, increasing energy efficiency, reducing greenhouse gas emissions, and promoting economic growth.

A robust R&D portfolio should extend measured treatment toward distribution and end-use technology. The intent should be to develop technologies to provide cost-effective, high-efficiency, low-emitting appliances, to innovate next-generation distributed energy solutions, and to maximize the efficiency of the energy distribution system. Examples of advanced natural gas end-use technologies where R&D priority could provide significant benefit include:

- Gas fired heat pumps
- Desiccant dehumidification systems

[7] The following examples were developed by AGA and also appear in the 2011 National Petroleum Council Demand Task Group report on North American Resource Development.

- Radiant heating projects
- Combined heat and power systems
- Renewable energy backup
- Gas/electric hybrid technologies
- District heating systems and applications
- Gas/electric hybrid technologies

R&D funding to develop advanced natural gas technologies can help realize the benefits of direct-use, which can contribute to a more robust and secure energy future.

End Notes

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